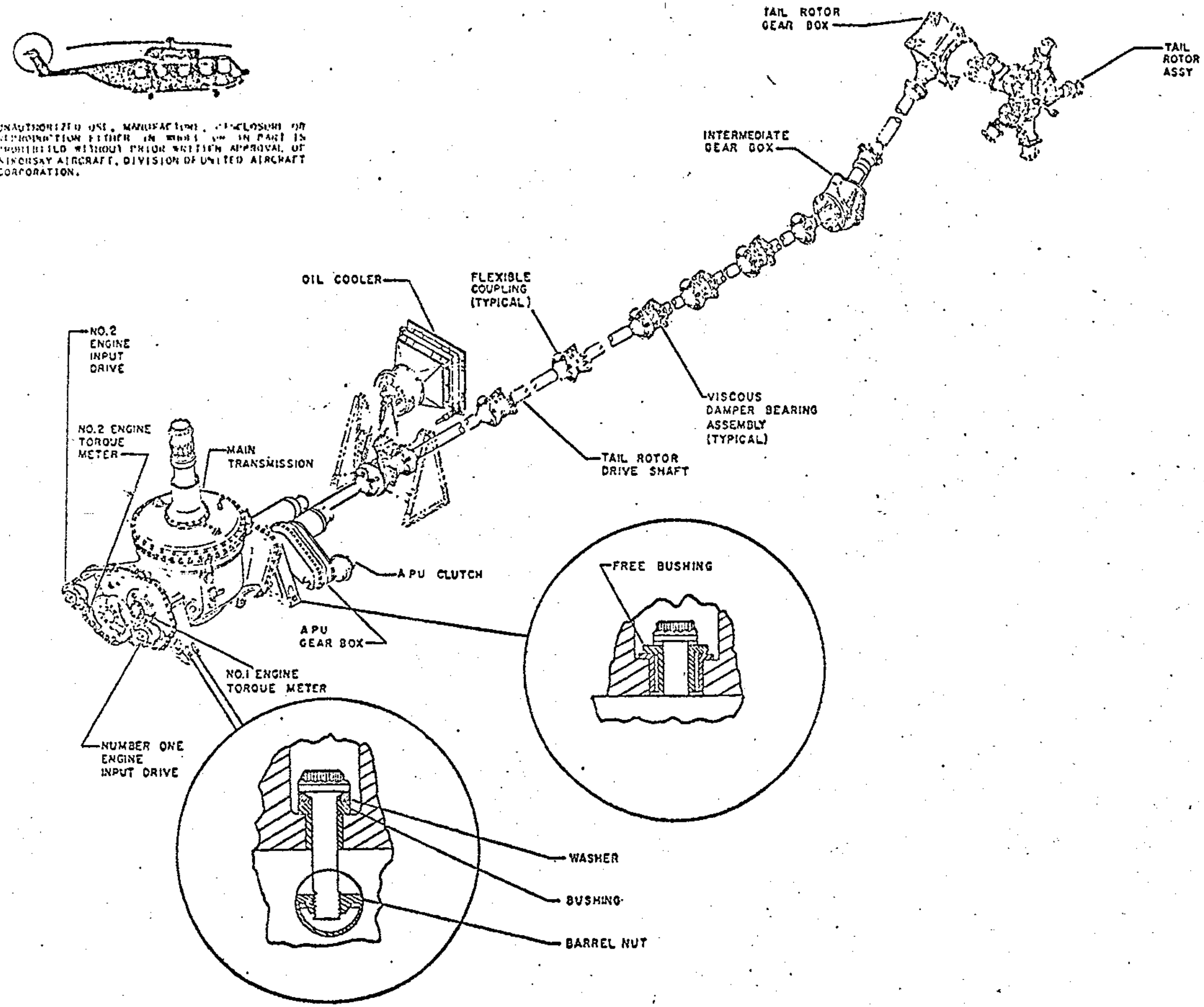
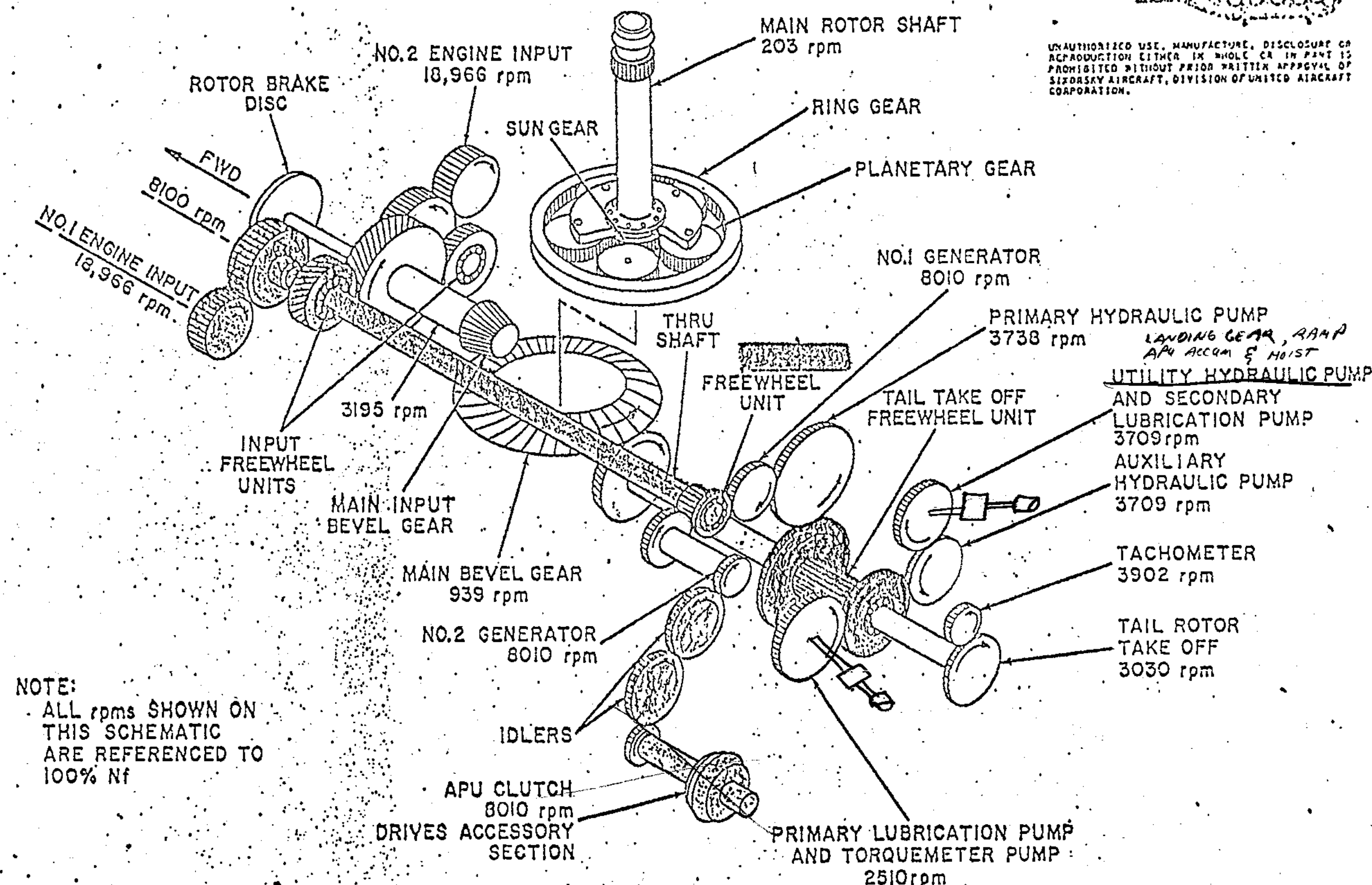


MAIN TRANSMISSION SYSTEM

Sikorsky Aircraft



MAIN TRANSMISSION SCHEMATIC

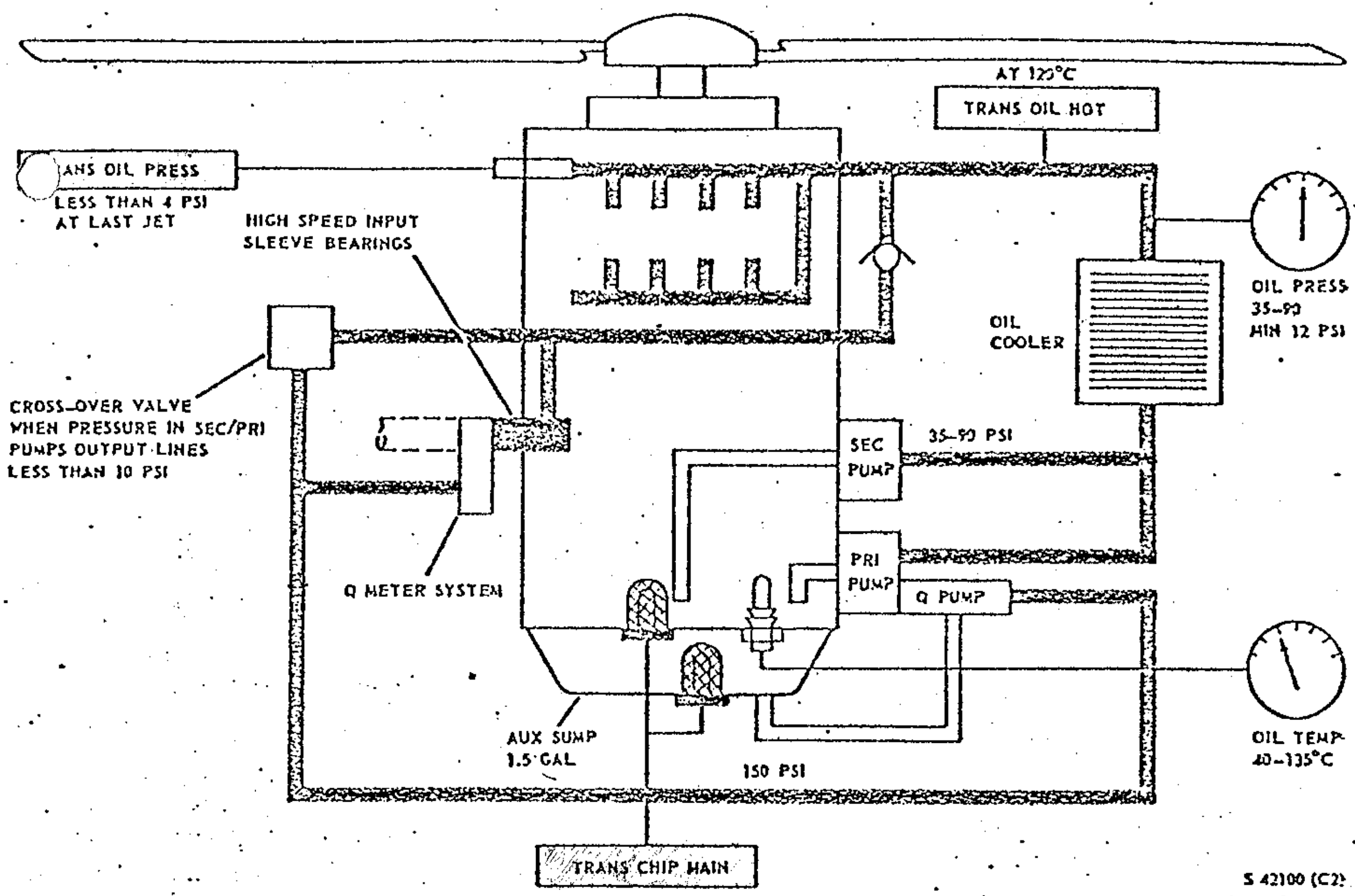


Figure 1-9A. Main Transmission with Auxiliary Sump

—{ENTER A MINIMUM POWER DECEND}—

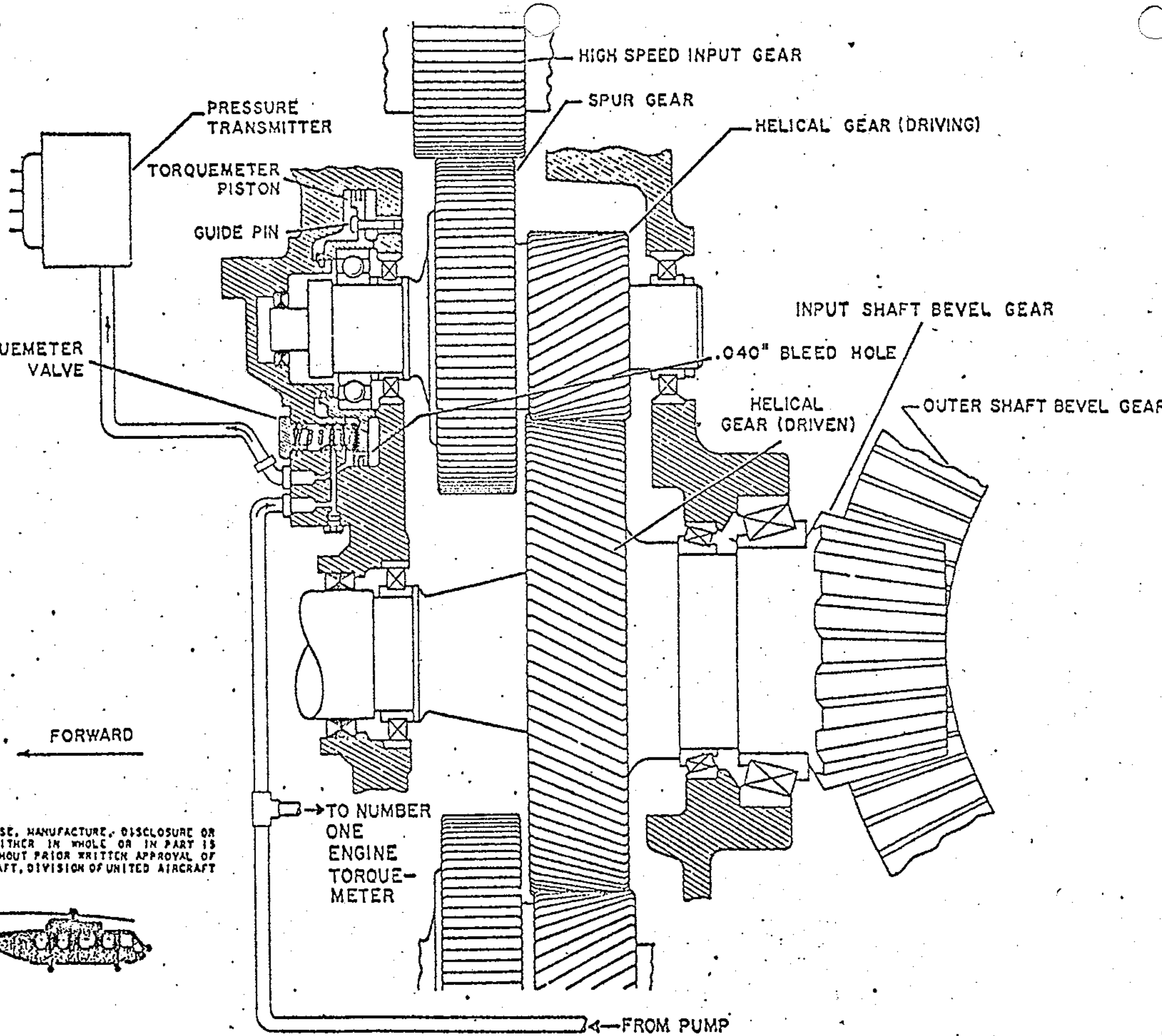
ZERO OIL PRESSURE + TRANSMISSION CHIP

HIGH ENGINE POWER

TRANSMISSION NOISES

YAW KICKS.

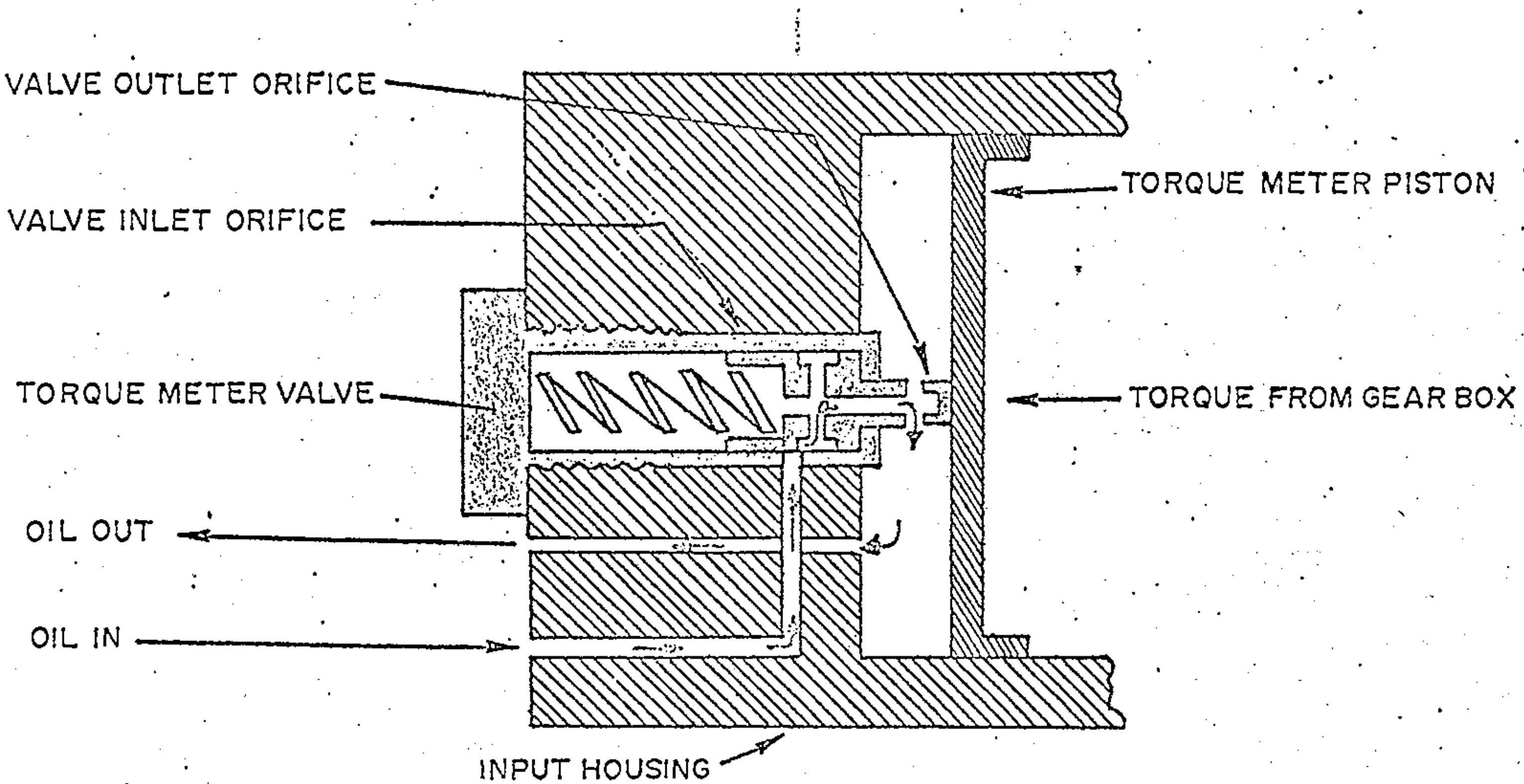
ZERO TORQURE



TORQUEMETER OIL SCHEMATIC

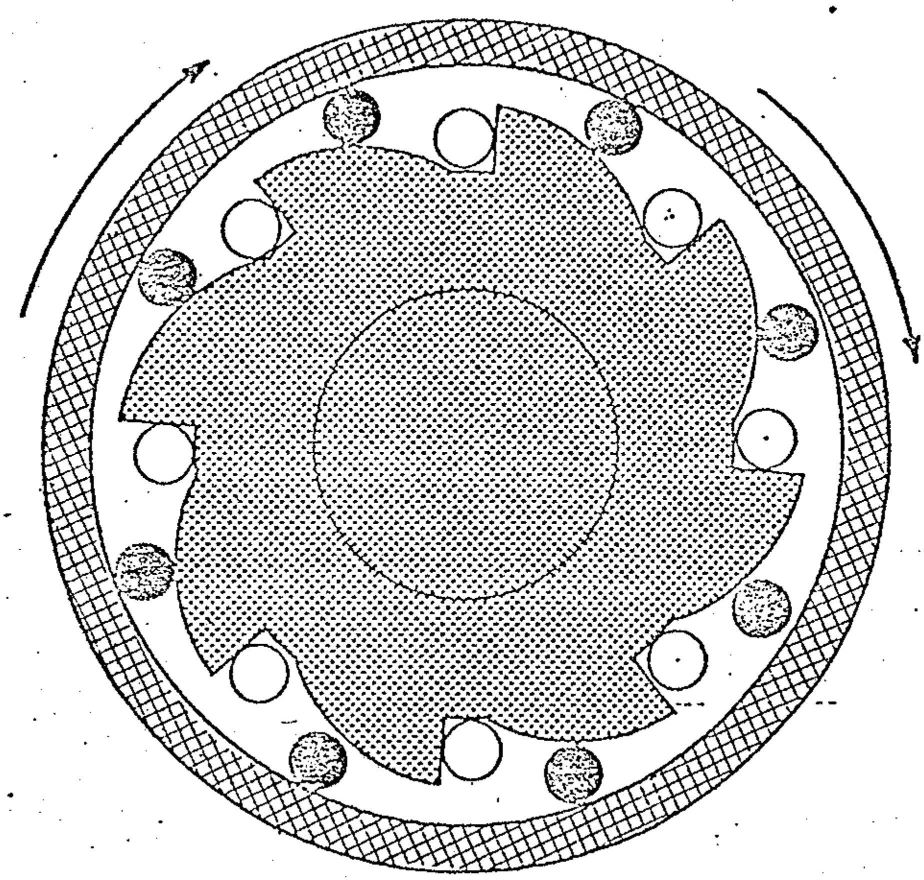
HH-3F
T2.1.37
REV I

TORQUEMETER VALVE



AS TORQUE IS APPLIED, THE TORQUEMETER PISTON PUSHES AGAINST THE TORQUEMETER VALVE, CAUSING IT TO CRACK OPEN. AS THE VALVE OPENS IT ALLOWS SOME OF THE 150 PSI TO ENTER THE VALVE, THE AMOUNT OF PRESSURE BEING PROPORTIONAL TO THE AMOUNT OF VALVE OPENING. THE OIL PRESSURE THAT HAS BEEN METERED INTO THE VALVE NOW FLOWS OUT HOLES IN THE END OF THE VALVE AND INTO A METERED OIL CHAMBER FORWARD OF THE TORQUEMETER PISTON. THIS CHAMBER IS CONNECTED BY A DRILLED PASSAGE TO AN OUTLET THAT LEADS TO AN EXTERNALLY MOUNTED PRESSURE TRANSMITTER.

FREE WHEELING UNIT



○ Roller bearing in autorotation

◍ Roller bearing in powered flight

In powered flight, with the rotor brake released, inertia and centrifugal force cause the roller bearings to move out of the grooves in the free wheeling cam and mechanically couple the engine to the rotor system.

In autorotation, with the blades at flat pitch and rotor inertia retained, a decrease in engine RPM with respect to rotor RPM causes the roller bearings to retract into the grooves and uncouple the engine from the rotor system.

I. OPERATION OF A BASIC SERVO

A servo mechanism, commonly called a servo, is a device for positioning a load with respect to an input signal capable of furnishing only negligible power. Its operation depends upon the difference between the load's actual position and its desired position, therefore some system must be devised to compare the load's position with the input signal. If the load's position, when compared with the input signal, leaves no error, the load is at the desired position; if the comparison leaves an error, the servo acts to change the load's position and reduces the error to zero.

The system that transmits the load's position back to the input for comparison with the input signal is called feedback or follow-up. The feedback is connected to the output in such a manner that it automatically and continuously feeds the load's position back to the input. The feedback allows the output to move the load an amount proportional to the error, and then the servo stops moving.

The power for driving a servo must come from some external source. In the case of a hydraulic servo, the power is generated by pressurized hydraulic fluid. The input signal controls the direction and volume of fluid flow, and the fluid is directed into a cylinder that has a movable piston with a predetermined surface area, which determines the force available. The distance through which the piston moves is determined by the feedback system. The servo, then, can amplify distance, or power, or both.

Since the hydraulic servo amplifies both power and distance with precision, it readily adapts to aircraft flight control systems. In the case of the auxiliary hydraulic servo, it positions the flight controls accurately and also provides an excellent point to connect AFCS to the flight control linkages. Although the power output from AFCS is less than one watt, it can control the auxiliary servo whose power output is great enough to overcome the feedback forces of the main rotor blades.

Most hydraulic servos, however sophisticated, can be said to have four basic requirements. First, a bypass valve used as a means of passing fluid from one side of the power piston to the other when there is no pressure applied to the servo. The bypass valve must close with the application of pressure. Second, a spool valve (pilot valve) used to direct fluid under pressure to either side of the power piston and at the same time provide a return path to the side opposite. Third, a sloppy link used to enable the pilot to move the spool valve. The sloppy link must close and become a pivot point when pressure is not applied. Fourth, mechanical feedback, commonly referred to as degenerative feedback or followup, used to prevent the servo from running away from itself.

II. DESCRIPTION OF THE AUXILIARY HYDRAULIC SERVO

The auxiliary hydraulic servo, located in the control closet, consists of four independent servos constructed as a unit (Refer to T3.1.60). Each servo of the unit amplifies the power of the pilot's and/or AFCS' input to the flight controls and transfers this power to the rotor blade linkage. Although the operational concept of the four servos is similar, they have small differences and refinements to enhance their function.

Each of the four servos function in a single area of control. They provide power amplification for the fore/aft and lateral movement of the cyclic stick, vertical movement of the collective stick and motion of the directional control pedals.

The auxiliary hydraulic pump, located on the accessory pad, aft of the main gear box, supplies hydraulic power to the auxiliary servos, the stick trim system, and the pedal damper.

III. SERVO OPERATION (Refer to T3.1.61)

A. Preliminary Conditions

Although the operation of all servos is similar, the collective servo is the least sophisticated of the group; therefore it has been singled out for a detailed analysis. T3.1.61 shows the collective servo in a pressurized state with the bypass valve and spool valve closed. Hence, with no input signal, hydraulic fluid in the power cylinder locks the piston in place. To initiate power piston movement, an input signal must displace the spool valve causing it to direct hydraulic fluid under pressure to the power piston.

Pressurized fluid enters the servo at two points. At point A the pressure actuates the sloppy link and bypass actuator which performs two functions. It compresses the spring in the bypass cylinder closing the bypass valve and separates the surfaces that have been clamping the sloppy link pin. This action releases the sloppy link pin which no longer performs as a pivot point, but functions as a part of the input linkage, free to move back and forth with input signals from the pilot's stick.

Pressurized fluid also enters at point B where it flows through two metered orifices and then through two variable orifices at the AFCS operated flapper valve. The flapper valve, spring loaded to the center position, allows equal volumes of fluid flow through each orifice to the return line which leads back to the fluid supply tank. With equal flow of fluid through each orifice, equal pressure is developed in the cavity at each end of the spool valve causing the springs at the ends of the spool valve to center it within the carriage.

With the servo pressurized as outlined, the pressure at point A holds the bypass valve closed, maintaining the spring in the bypass valve actuator compressed. The pressure at point B causes a continuous flow through the metered jets and the flapper valve orifices. The constant flow servos two functions. It allows the fluid to circulate through the auxiliary hydraulic system which carries heat away from the hydraulic pump and, in the servo, it allows the AFCS flapper valve to change the pressure at the orifices by restricting the flow through one or the other, causing a pressure differential across the spool valve. With the flapper valve in its neutral position, the pressure at its orifices is equal and this reflects equal pressure to the ends of the spool valve. While the spool valve rests in its centered position and with no input signal from the pilot's controls, pressurized fluid cannot reach the power piston and it remains stationary.

B. Pilot Input

Assume normal operation of the servo from a pilot input with no input from AFCS and disregard the action of the open loop spring. When the pilot's input causes point C to move up, point D acts as a pivot point since the power piston is hydraulically locked in place. The upward motion causes the sloppy link pin to move up while the differential input link pivots clockwise at point D. As the differential input link moves, it's motion at the sloppy link pin is transmitted through the transfer link to the feedback link which rotates clockwise about point E. The rotation of the feedback link causes the spool valve carriage to move down. Since equal forces on the ends of the spool valve hold it centered in its carriage, it moves down with the carriage. Movement of the spool valve opens two ports. The open port at F allows fluid under pressure to reach the power piston and start it travelling up. As the power piston begins travelling up, the fluid in the upper portion of the power cylinder must escape. To provide an escape path, port G was opened at the same time as port F. Port G provides a direct line through return port R for the escaping fluid which is piped back to the storage tank for re-use.

When the pilot stops his input motion, the differential input link rotates counterclockwise its connection to rod C because of continued motion of the power piston. The sloppy link pin moves down, pulling the transfer link down and the carriage moves up. The upward movement of the carriage repositions the spool valve until it closes ports F and G. When Port F closes, the power piston stops and the feedback action is complete.

C. AFCS Input

1. Without open loop conditions

Since the spool valve controls the power piston, it follows that AFCS should control the spool valve. With T3.1.61 as a guide, the flapper remains spring loaded to its center position when no AFCS signal exists. The flapper actuates with input to its two coils from the AFCS amplifier. These electrical signals cause the flapper to pivot in the appropriate direction about point H. This pivoting action retards fluid flow through the proper variable orifice, incrasing the pressure behind this orifice and unbalancing the pressure at the ends of the spool valve. Since the spool valve rests between springs of equal tension, the unbalance of pressure causes a compression of one spring an an extension of the other. The spool valve displaces within its carriage and opens port F and G the same as when the pilot's input moved the spool valve.

With the flapper displaced, the spool valve moves due to the pressure differential and directs fluid under pressure to the lower end of the power piston and the power piston begins moving up. As the piston moves up, friction in the control rods and bellcranks causes poin J to act as a pivot point, and when point D moves up, the sloppy link pin must move down pulling the transfer link down. The feedback link pivots at E and the carriage moves up. The upward movement of the carriage shifts the spool valve upward. This action continues until the movement of the power piston has closed port F. As long as the flapper valve remains in the displaced condition, it causes an unbalance of pressure at the ends of the spool valve which holds the spool valve away from the central position in its carriage an amount proportional to the pressure unbalance. When the AFCS signal that displaced the flapper valve disappears, and the flapper returns to center, the pressure at the ends of the spool valve equalizes and the springs force the spool valve back to the center of the carriage. This action opens the port that allows pressurized hydraulic fluid to reach the upper part of the power piston and it starts a downward movement which continues until the linkage repositions the carriage and port F closes.

2. With open loop conditions

The explanation to this point has neglected the function of the open loop spring. Although its purpose and function will be better understood after a discussion pertaining to the general philosophy of the altitude channel, its mechanical application to the system will be explained here. An open loop spring performs similar functions in the yaw servo; however, the following will be restricted to the collective operation.

Assume the AFCS input signal were large enough to cause the flapper valve to displace about half of the distance between its neutral and maximum position. This would cause motion of the power piston. If the power piston movement is up, then point D moves up and the differential input link begins to pivot at point J, and the sloppy link pin moves down. This motion is transmitted back to the spool valve to begin the follow up and valve closing action. At the same time the pin acts to compress the open loop spring. As the spring compresses, a point will be reached when the force to compress the spring is greater than the force to overcome the friction that holds point J stationary. When the spring compresses, to the point where point J moves, the linkage back to the collective stick causes movement of the stick.

NOTE

The friction lock on the collective stick must allow stick movement during open loop operation. When point J moves, the sloppy link pin becomes a pivot point and follow-up movement that was closing the spool valve stops. The spool valve remains open, the power piston continues to move, and the collective stick continues its upward motion.

Since all of the action was initiated by an error signal from AFCS, the climbing reaction of the helicopter which resulted from the upward motion of the power piston corrected the error and allowed the flapper valve to recenter. When the flapper valve recentered, the spool valve returned to its center position and stopped the flow of fluid to the power piston. At this point, the collective control has been repositioned and the AFCS has a new reference point to work around. The new reference being determined by how far the collective stick moved from its original position.

The open loop spring, by restricting feedback, extends the amount of power piston movement that results from an AFCS signal whose amplitude exceeds the value necessary to compress the spring beyond a predetermined magnitude.

D. Cyclic Stick Trim System (Refer to T3.1.62)

With the small amount of friction encountered in the cyclic system between the cyclic stick and the auxiliary servo, and the small force necessary to actuate the servo, some method is required to hold the stick in a fixed position. During AFCS flight, the pilot may release the cyclic stick and allow AFCS to maintain a helicopter attitude whose reference is centered around the stick position.

The stick trim system in either cyclic servo consists of two electrically controlled hydraulic valves and a hydraulic piston mechanically attached to the cyclic linkage through a force gradient spring. Switches, located on the cyclic sticks, control electric power to the valves. Using T3.1.62 as a reference, the stick trim system is pressurized through a reducer that drops the hydraulic pressure from the auxiliary servo pump from 1500 psi to 60 psi before it enters the system. The 60 psi pressurizes the lower section of the trim cylinder and applies 60 psi to the left actuator valve. In this condition, the stick trim piston attempts to travel up, but is held locked in position by the fluid in the upper section that cannot escape because of the closed actuator valves. This action (both fore/aft and lateral) holds the cyclic stick spring loaded in one position. Without opening the valves, the pilot can move the stick by placing a force approximately 1 1/2 lbs. at the grip of the stick to start the movement and then approximately 1/2 lb. of force per inch of movement thereafter. Under these conditions, whe he ultimately releases the stick, the force gradient spring, which was compressed to allow the movement, will return the stick to its original position. This position is called the trimmed position and may be changed by actuating the trim valves with the TRIM REL switch on the cyclic stick.

When the pilot depresses the TRIM REL switch, the coils in both trim valves are energized and open the valves. This action allows the 60 psi to be returned through a restrictor orifice directly to the return line and releases fluid on both sides of the trim actuator piston. The pilot can then, move the piston freely through the full extent of its travel without depressing the force gradient spring.

When the pilot releases the TRIM REL switch, trapping fluid on each side of the actuator piston, he establishes a new reference position for the cyclic stick.

Another feature of the STICK TRIM SYSTEM is the four-way switch located at the top of the cyclic stick. This switch allows the pilot to actuate the stick trim system by energizing only one of the TRIM valves at a time. This allows precision trimming of the cyclic stick in either pitch or roll.

E. Pedal Damper (Refer to T3.1.64)

The yaw servo functions similarly to the collective servo but it includes a damper to limit the rate of movement of the directional control pedals. Without some rate limiting device, it is conceivable that a pilot could move the pedals fast enough to put excessive forces on the helicopter.

The damper, connected directly to the pedal linkage, receives fluid from the auxiliary hydraulic source and both sides of the movable portion of the damper are pressurized. With pressure applied, the bypass valve compresses the spring at its upper end and closes the bypass ports. With the ports closed, the movable portion of the damper must displace fluid from one side to the other when the pedals move. The displaced fluid, trapped by the differential check valve can only reach the other side by passing through a small orifice. The orifice is designed so that a very small flow of fluid can pass through it with maximum force from the pilot, thus limiting the rate that the pedals can move.

When the auxiliary hydraulic pressure is turned off, the bypass valve opens the bypass ports because of the force of its spring pushing the valve down. With the bypass valve open, only the mechanical friction of the directional control system limits the rate of pedal movement.

Another feature of the damper allows the pilot to move the pedals through a short distance before the rate restriction is applied. Spring loading of the movable part of the damper permits this action by causing the spring to compress before the input motion reaches the movable part. This gives the pilot small unrestricted movement of the pedals for limited actions, while the larger movements are subjected to the restricting action of the damper anytime the auxiliary system is pressurized.

F. Yaw Open Loop Spring (Refer to T3.1.64)

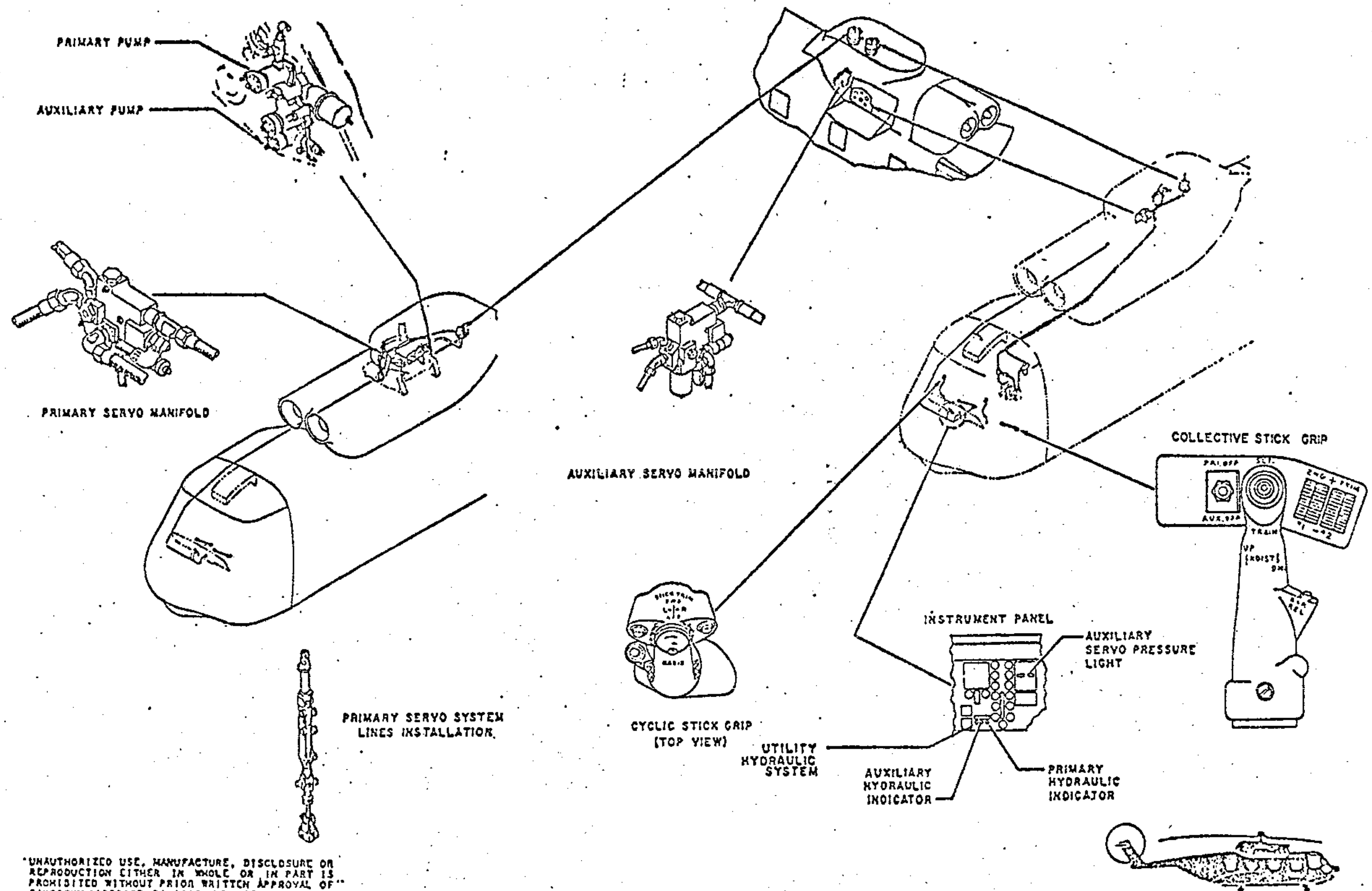
The open loop spring on the yaw servo functions similar to that described on the collective servo. Its purpose is to restrict the servo follow-up and cause the power piston to continue moving when a large signal is received from AFCS. Like the collective servo, the farther the spring compresses, the more the spool valve remains open and the faster the controls move. However, because of the restricting motion of the damper, the velocity of movement is limited to a speed determined by how much the spring is compressed holding the spool valve open, and how fast the fluid in the damper can be displaced. This speed is varied by adjusting the spring until the correct specifications are reached. The adjustments and procedures are laid down in a step-by-step form in Information Notice 61-65R, Open Loop Spring Adjustment Procedure.

During the adjustment procedure of the yaw open loop spring, a small gapiis left between the ends of the spring and the housing where it seats. This gap allows the power piston to move a short distance before the spring contacts its housing and permits a limited movement of the piston before the pedals begin to move. This movement, termed "proportional band", is the distance that AFCS signals can move the servo without affecting pedal movement. When the signal reaches an amplitude large enough to compress the spring, and the force necessary to compress the spring exceeds the force necessary to overcome the friction in the controls, the pedals move. Movement of the pedals gives the tail rotor a new reference to work from.

JW/RHO/lac
5/31/68

FK/ds
5/19/70 Rev. A.

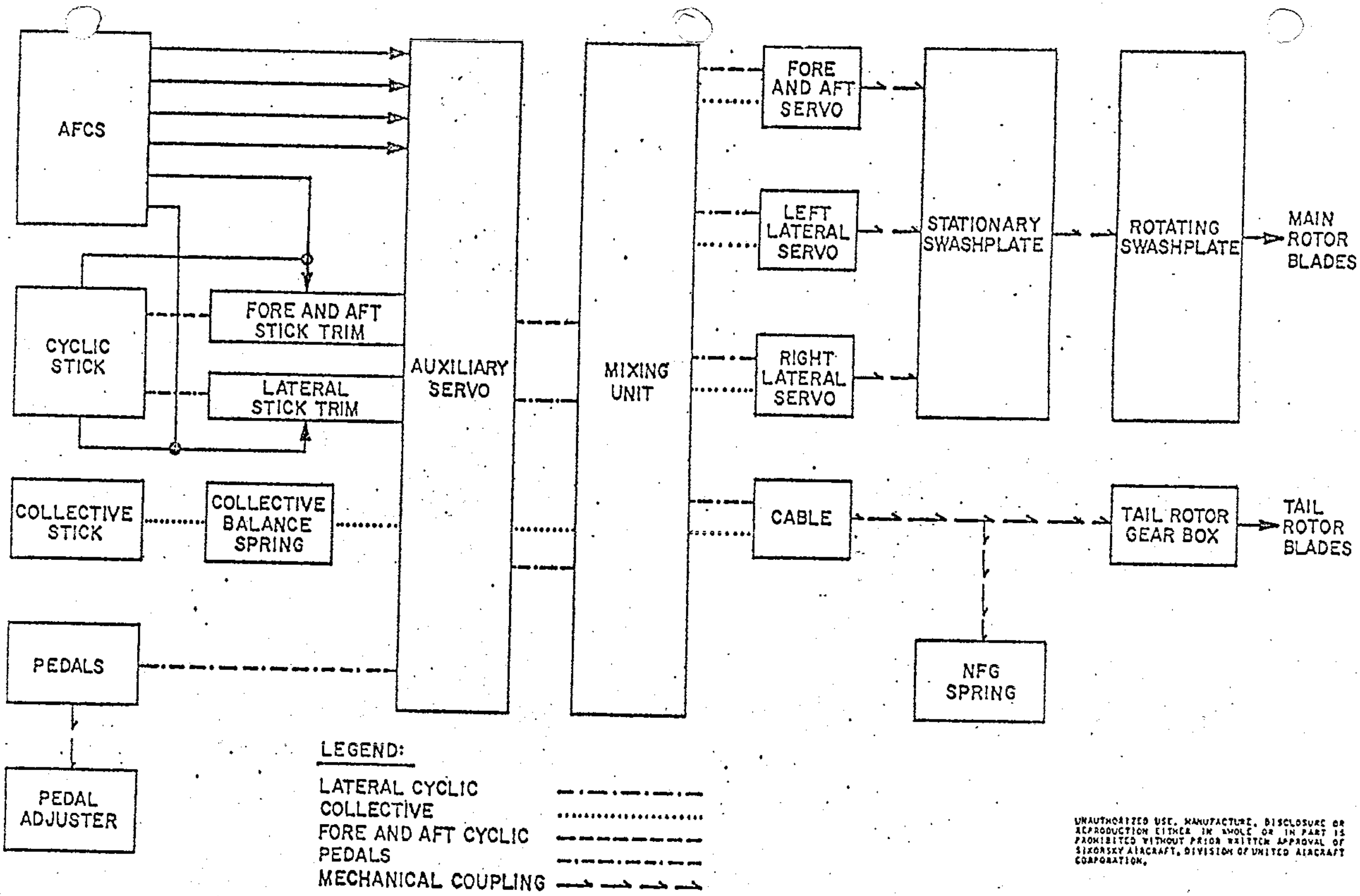
FK/ds
8/9/70 Rev. B

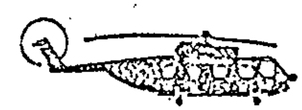


PRIMARY AND AUXILIARY SERVO SYSTEM COMPONENTS LOCATION

HH-3F
T3.1.49
REV 1

Sikorsky Aircraft

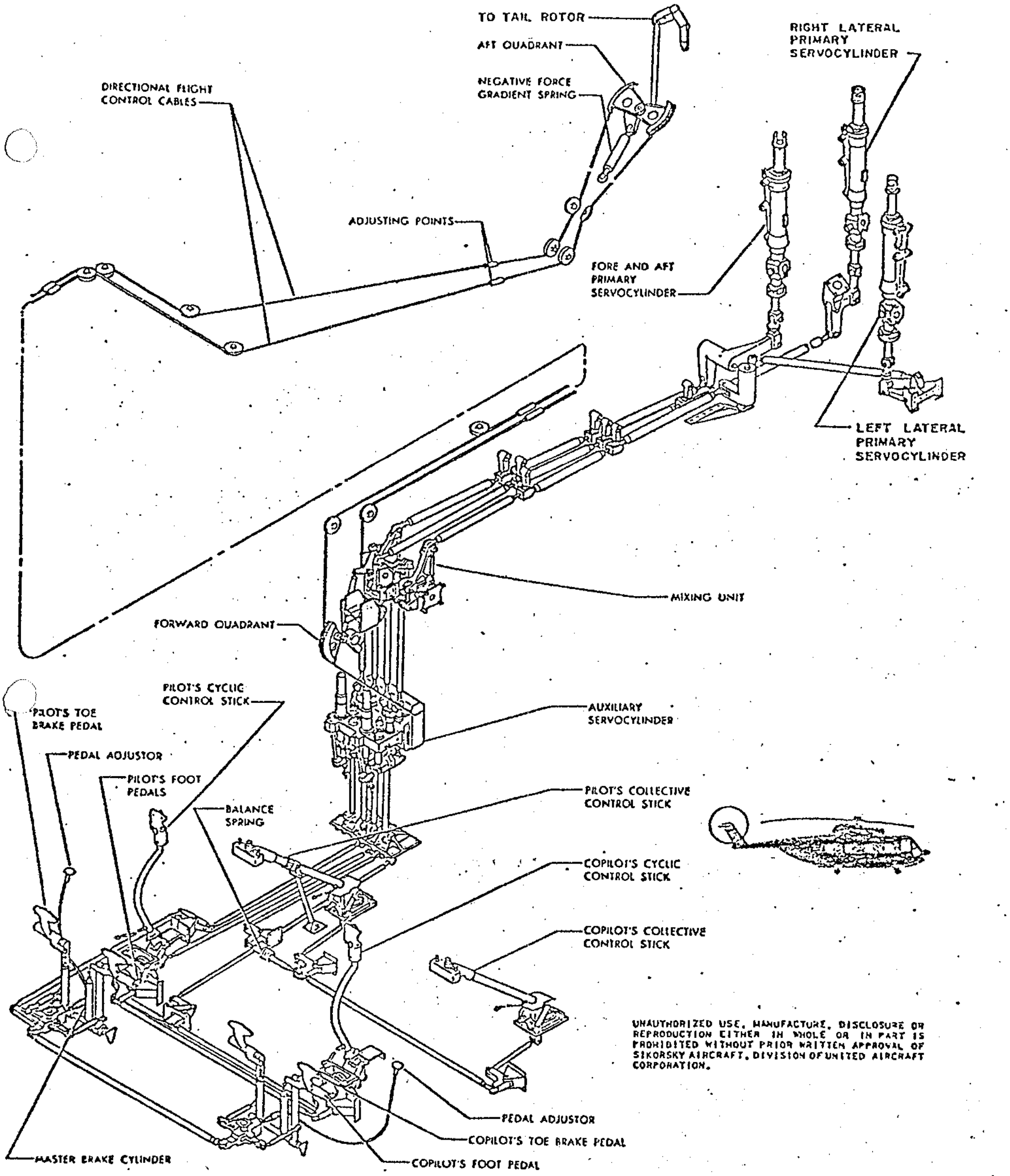




FLIGHT CONTROLS BLOCK DIAGRAM

Sikorsky Aircraft

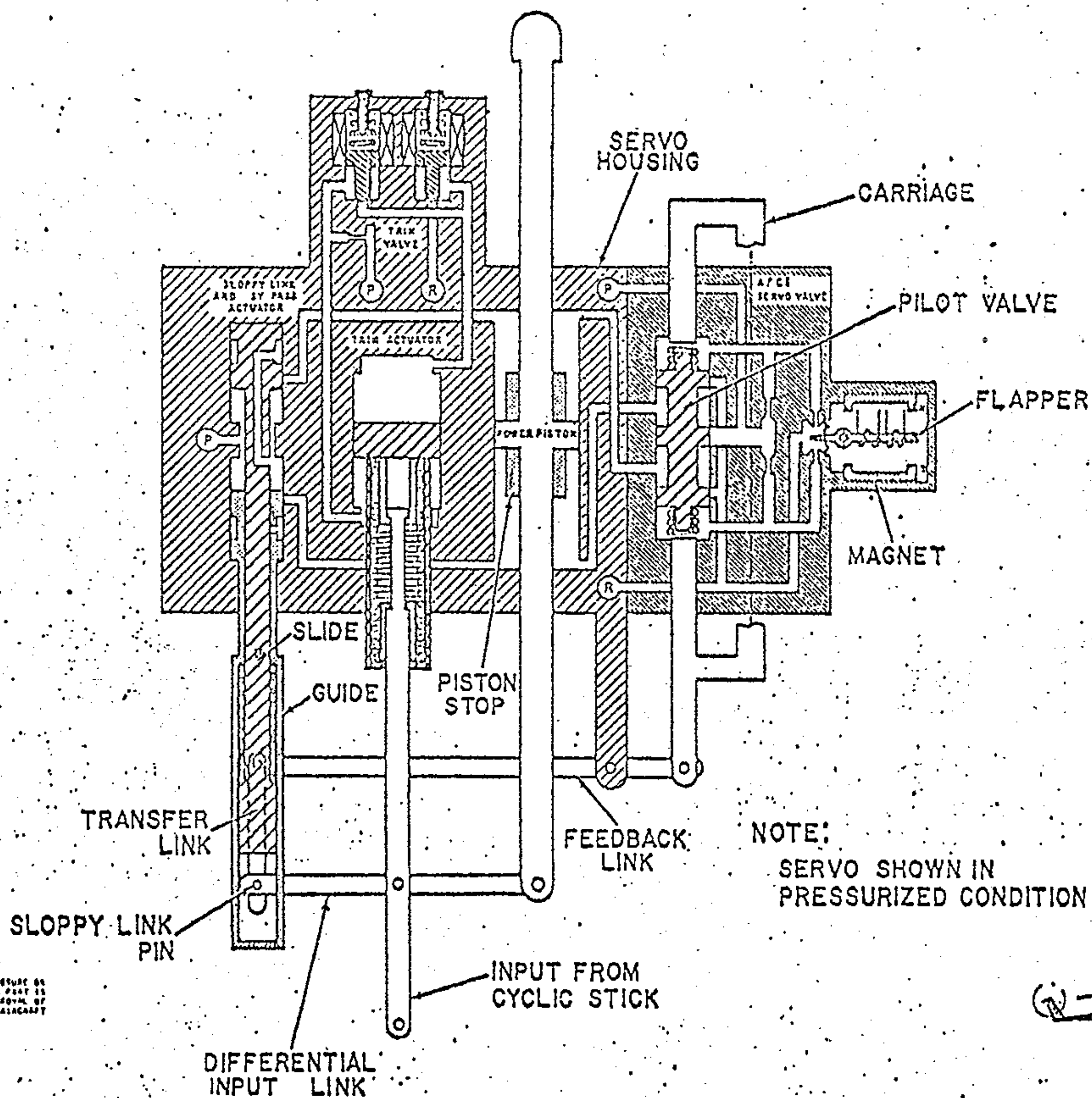
HH-3F
T3.1.65



FLIGHT CONTROLS GENERAL LAYOUT

HH-3F
T3.1.66

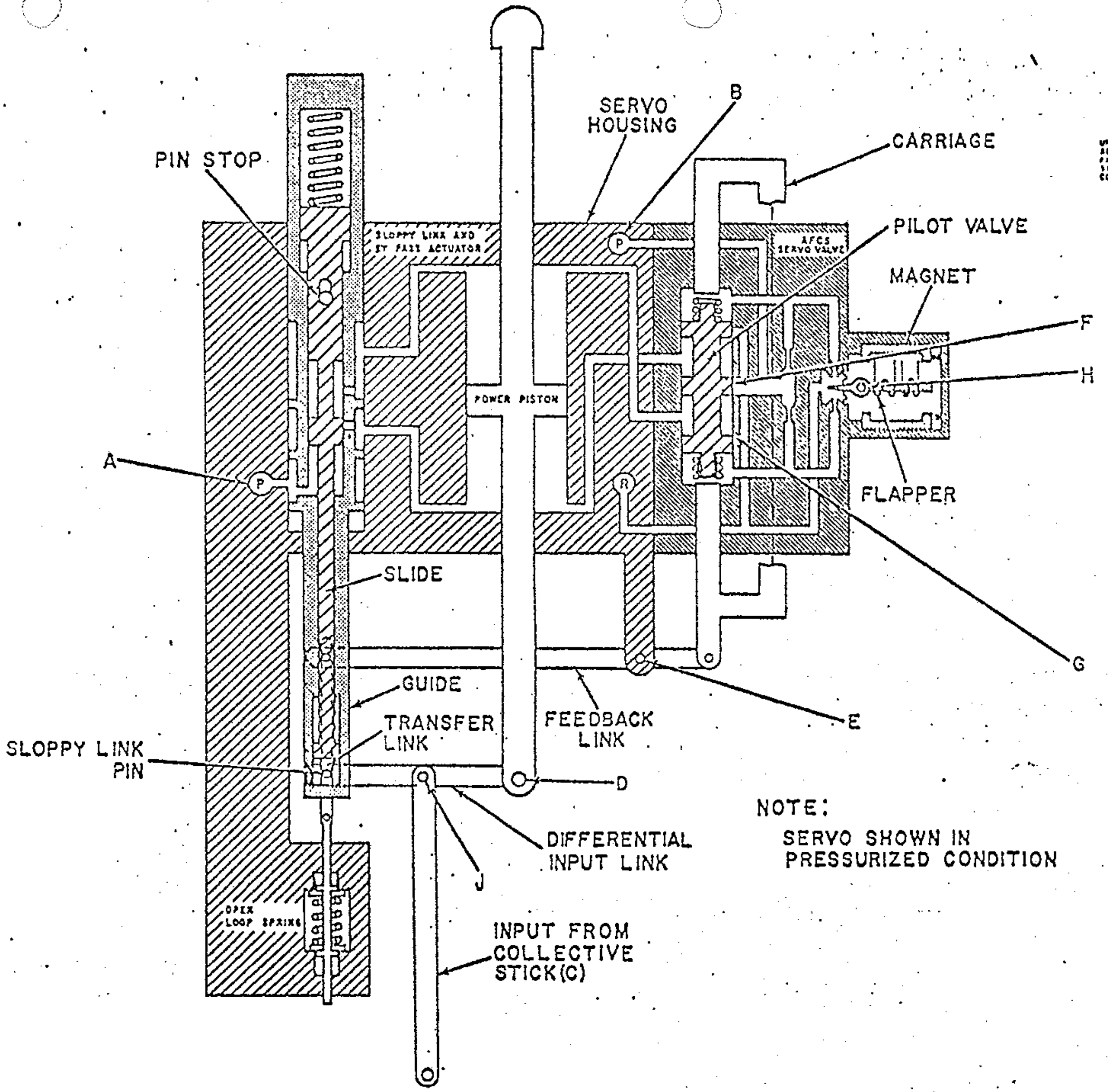
Sikorsky Aircraft — U A



AUXILIARY SERVO SCHEMATIC-FORE AND AFT/LATERAL

HH-3F
T3.1.02

Sikorsky Aircraft



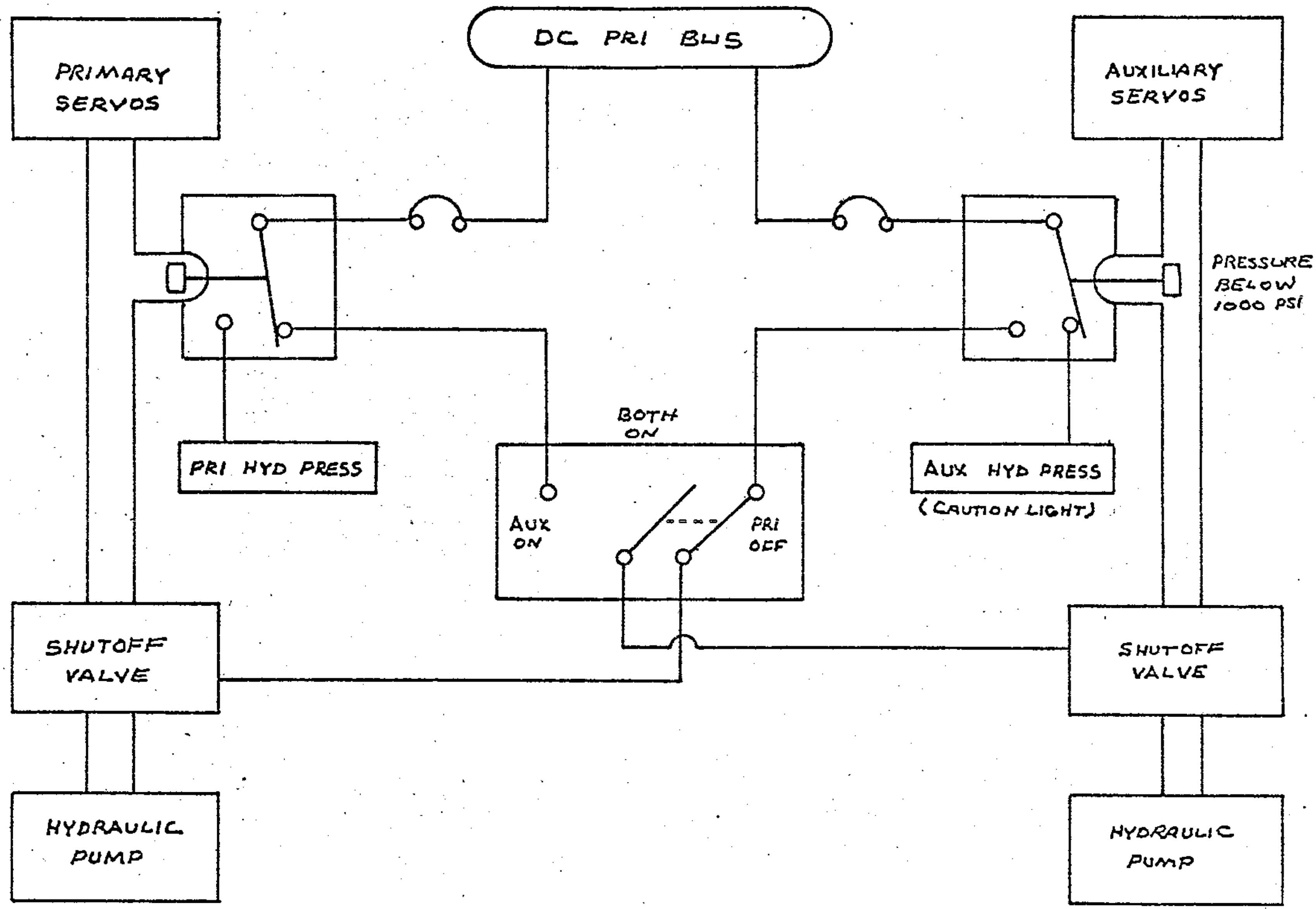
NOTE:
SERVO SHOWN IN PRESSURIZED CONDITION

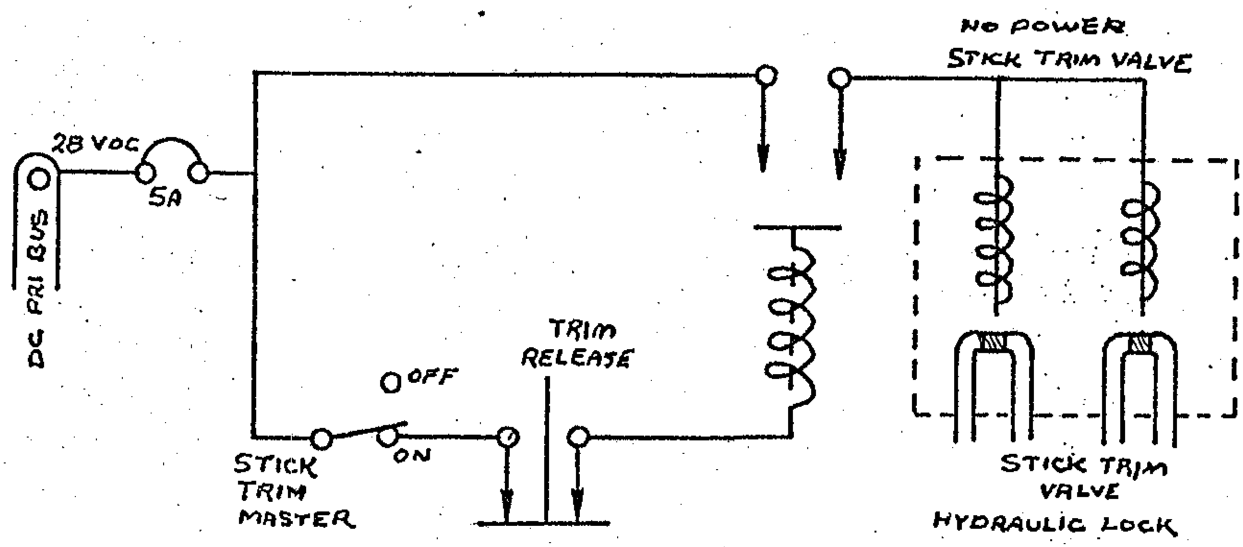
AUXILIARY SERVO SCHEMATIC-COLLECTIVE

Sikorsky Aircraft

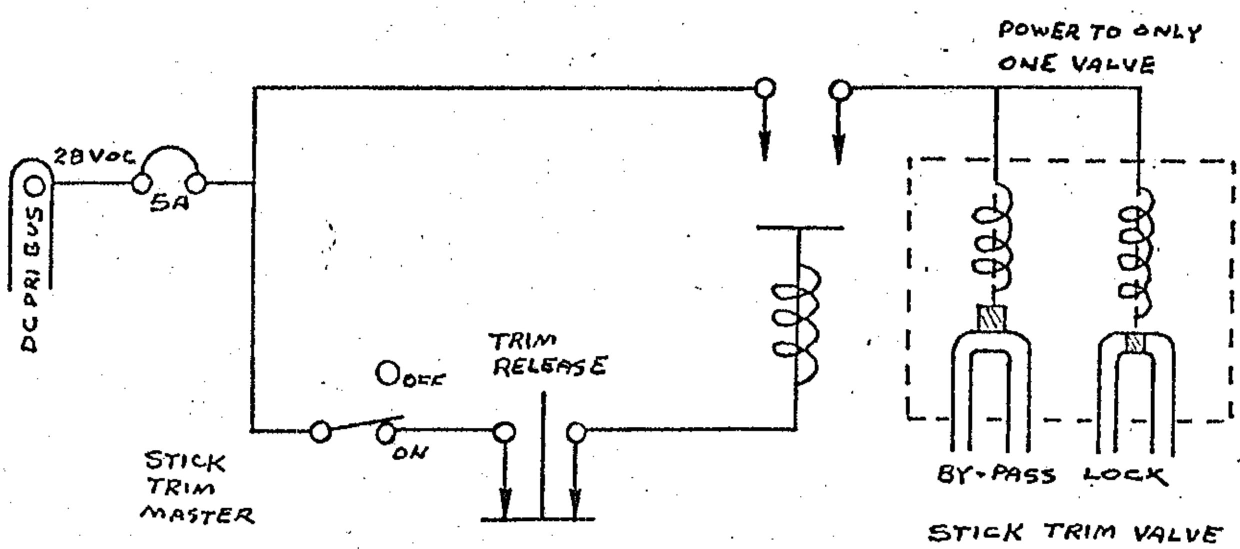
HH-3F
T3.1.61
REV1

SERVO I[illegible]ERLOCK SYSTEM

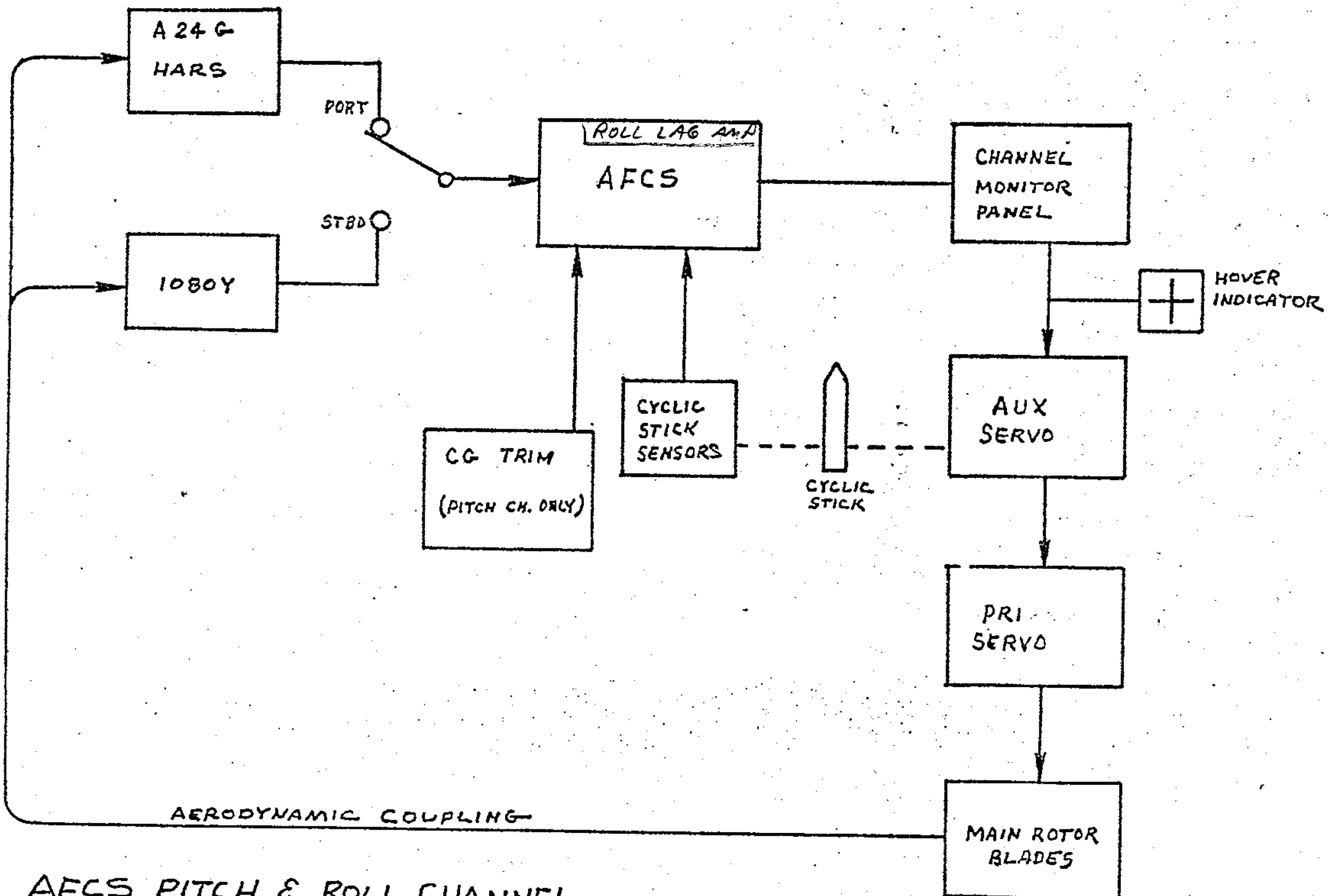




NORMAL CONFIGURATION

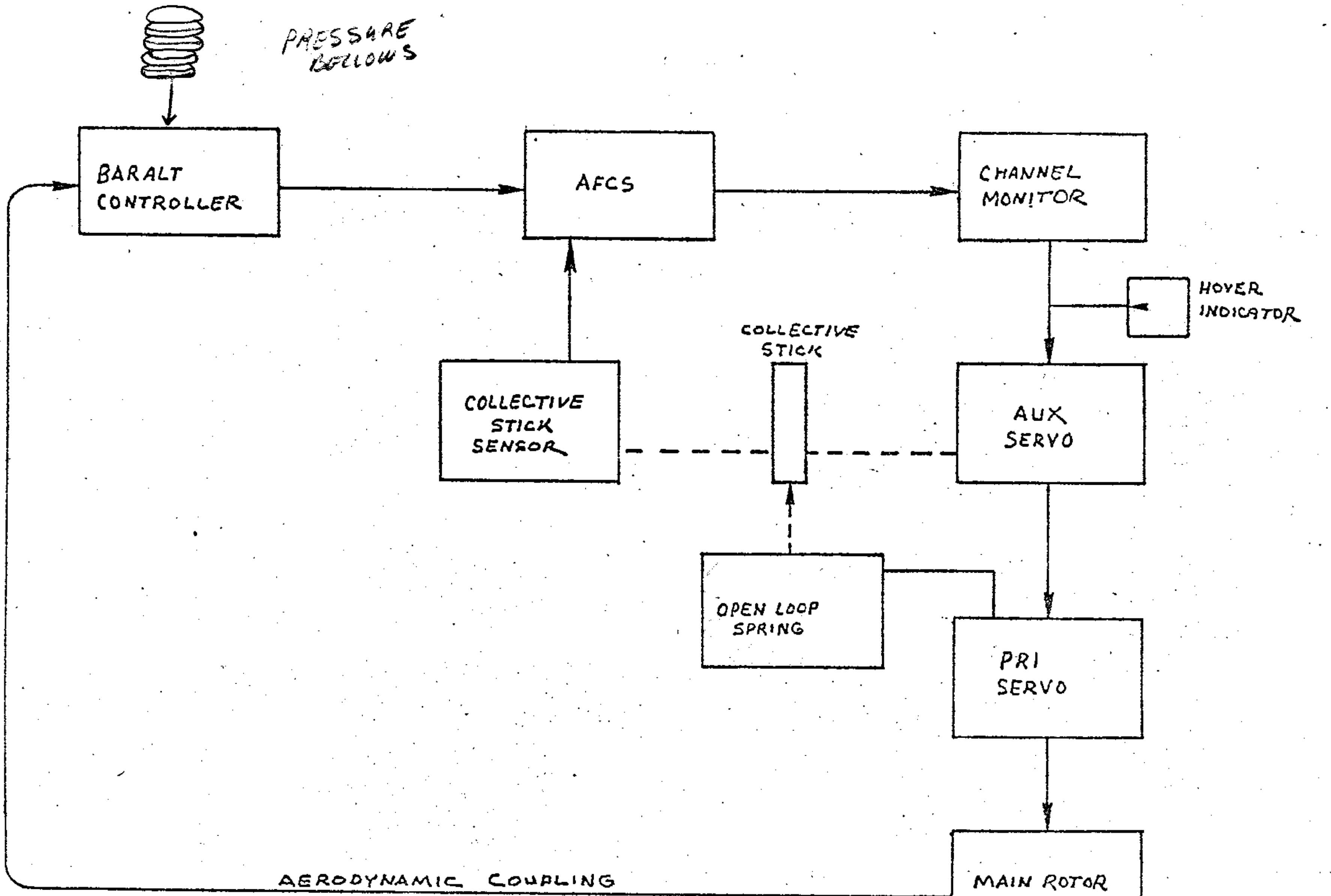


BEEPER VALVE MALFUNCTION



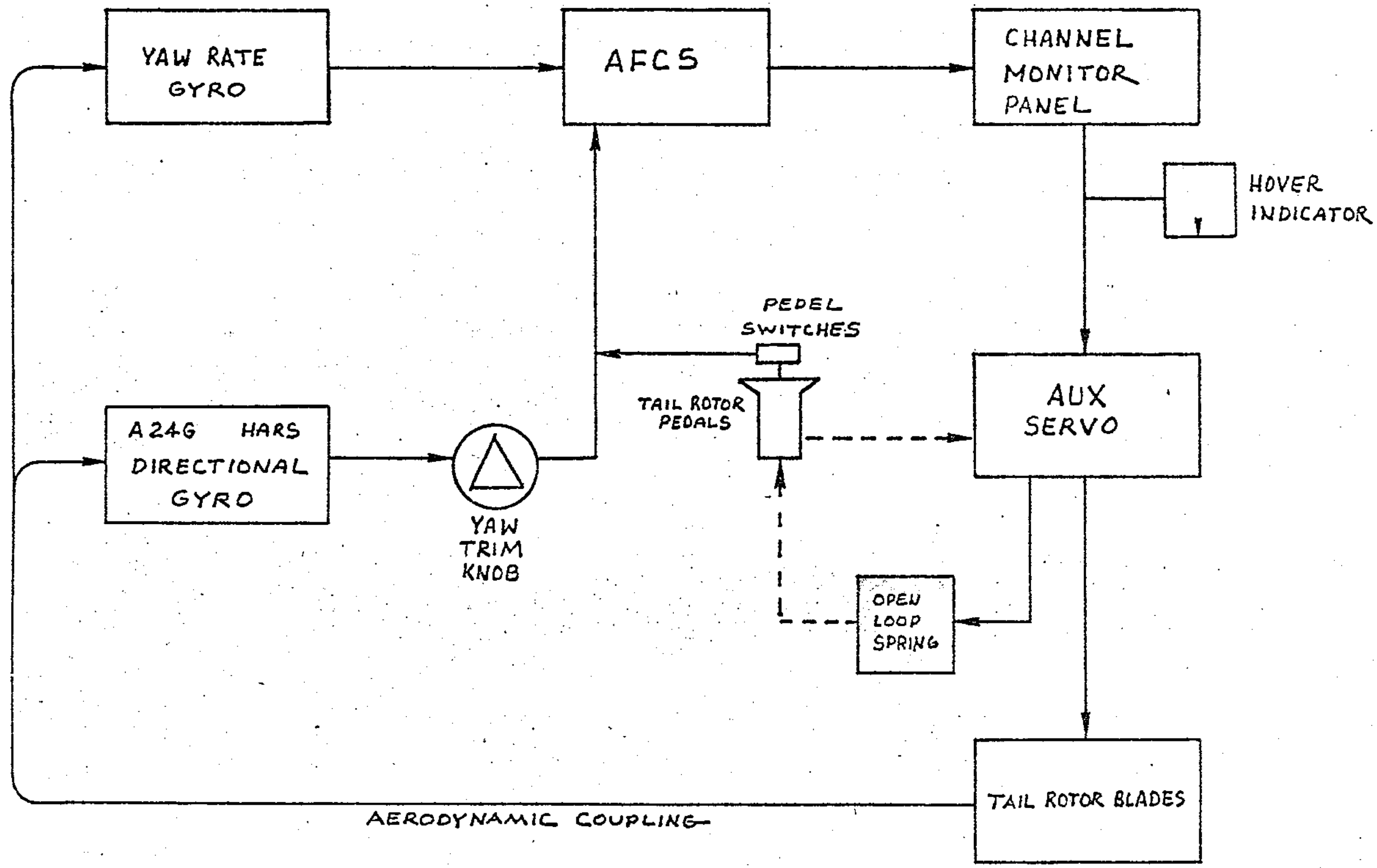
AFCS PITCH & ROLL CHANNEL

10% CONTROL AUTHORITY



AFCS COLLECTIVE CHANNEL

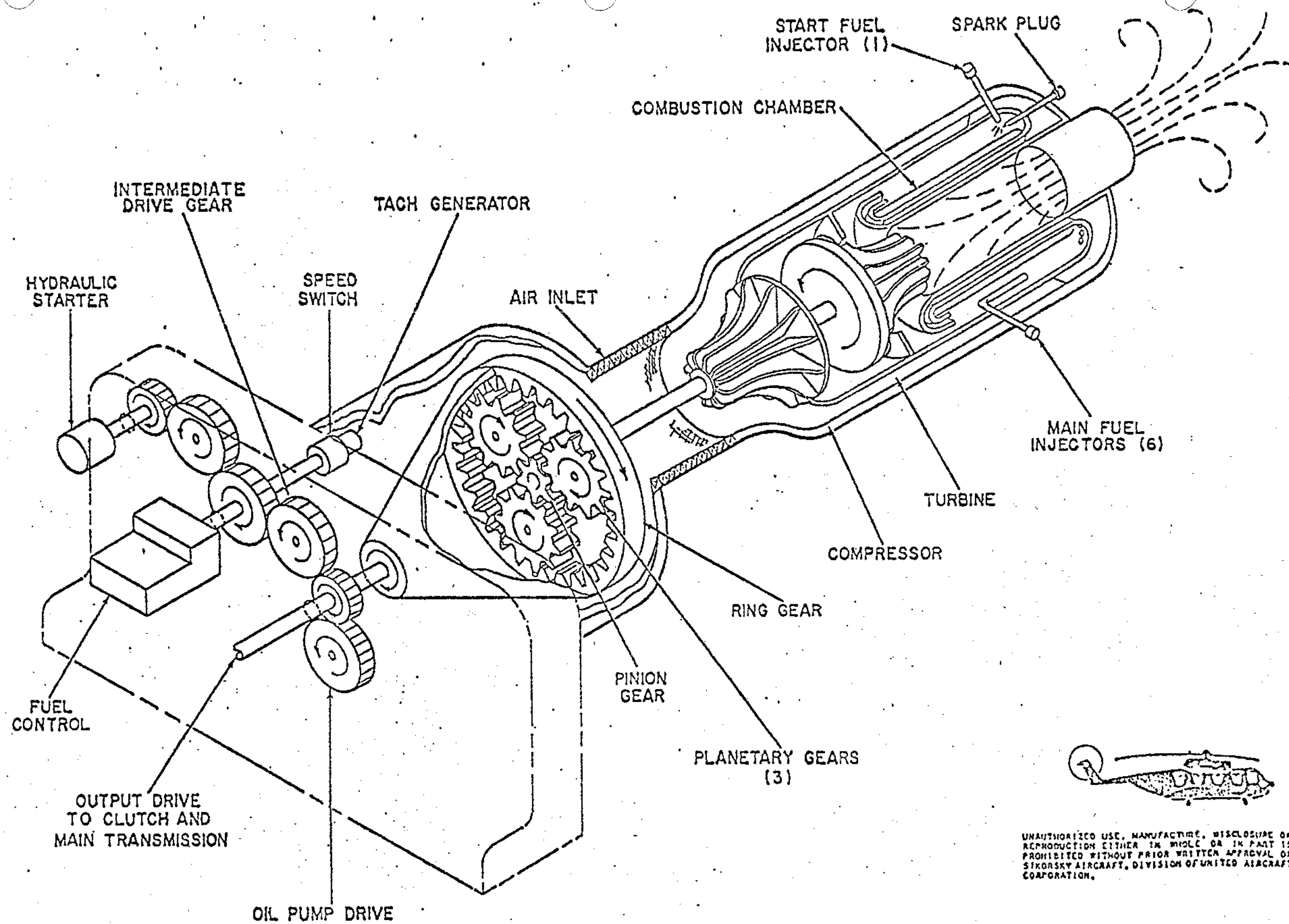
5 % CONTROL AUTHORITY
MOVES COLLECTIVE THRU OPEN LOOP SPRING MECH.



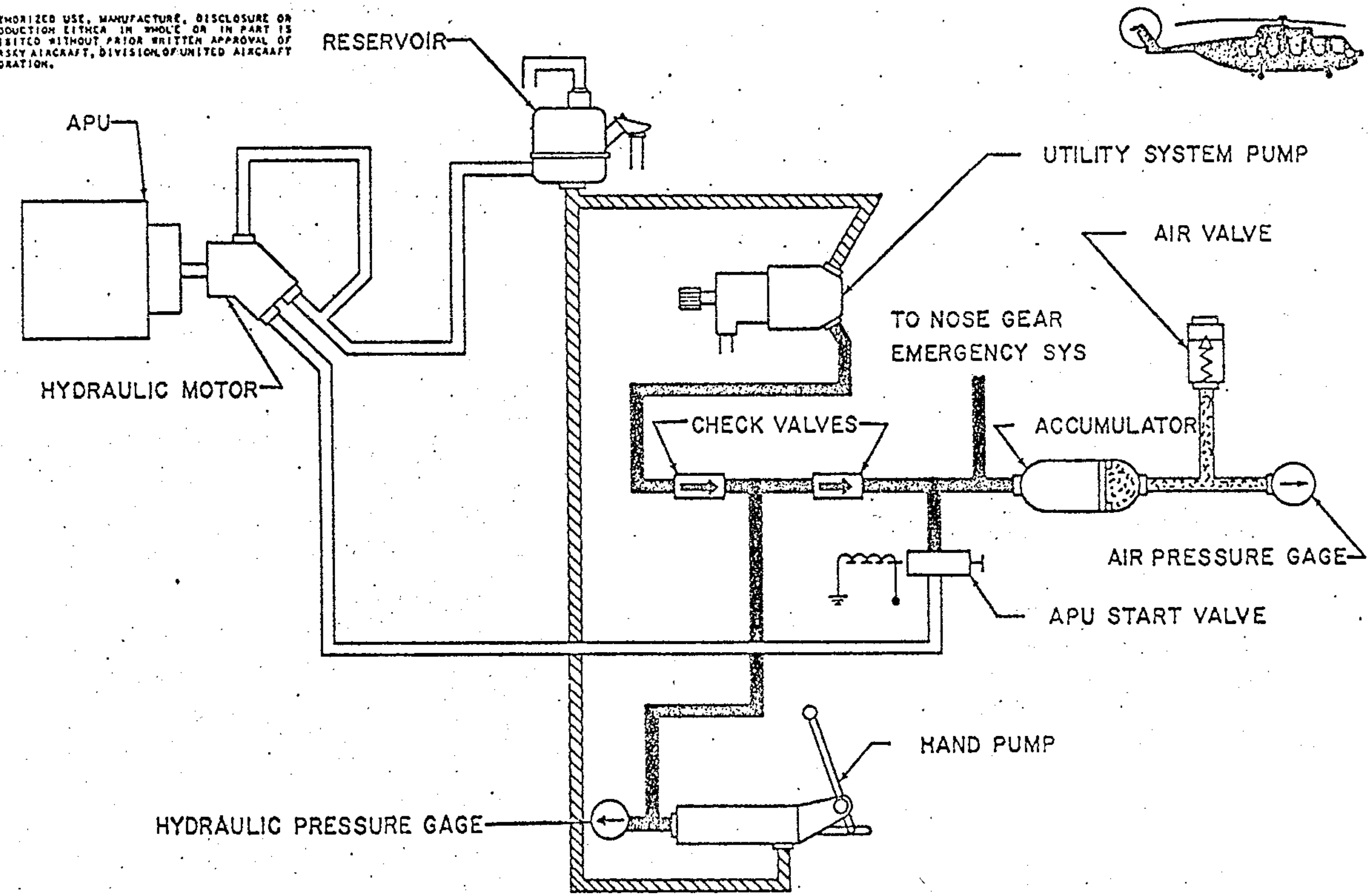
AFC YAW CHANNEL

5% CONTROL AUTHORITY

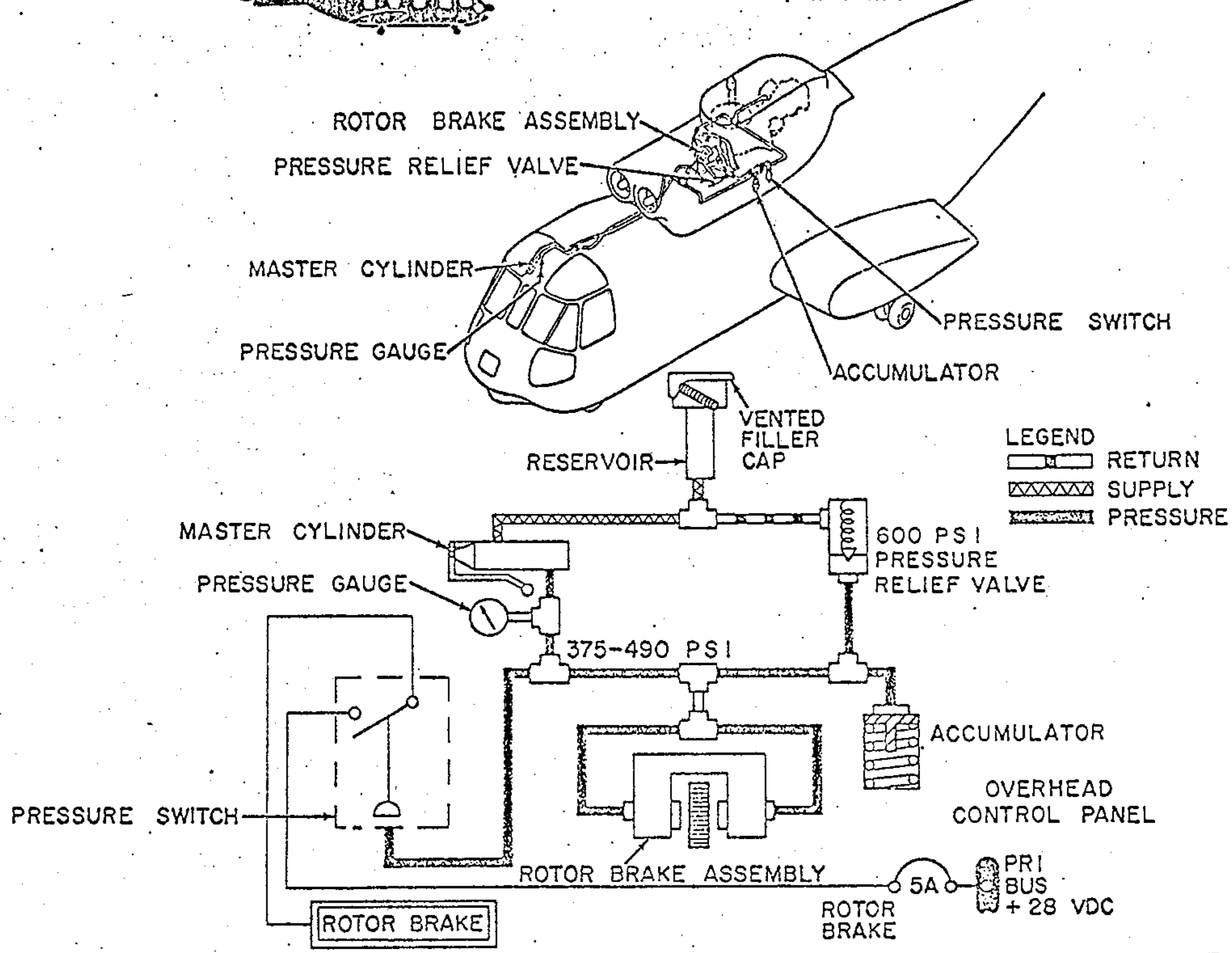
MOVES PEDELS THRU OPEN LOOP SPRING MECH.



APU GENERAL SCHEMATIC

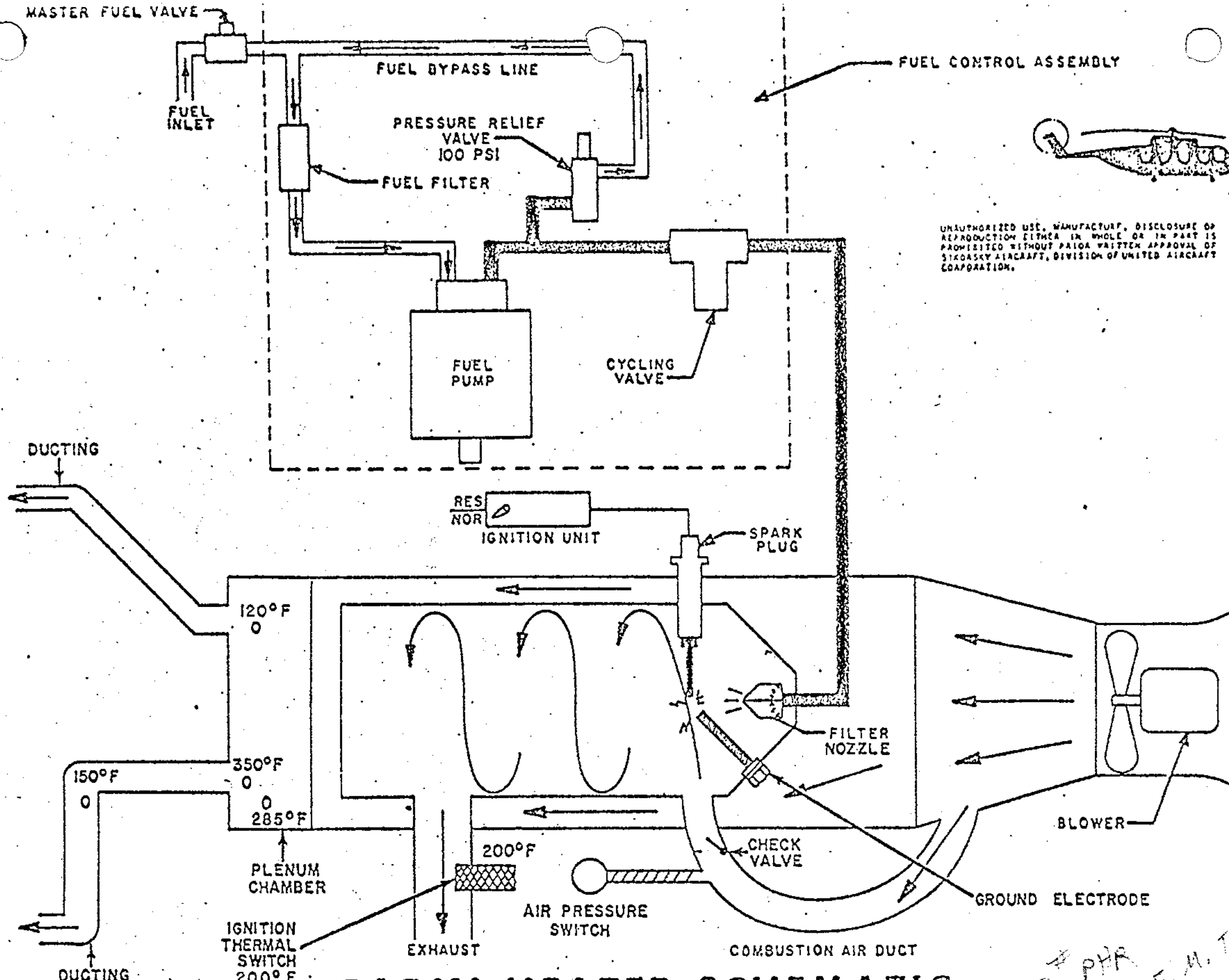


APU HYDRAULIC STARTER SYSTEM SCHEMATIC



ROTOR BRAKE SYSTEM SCHEMATIC

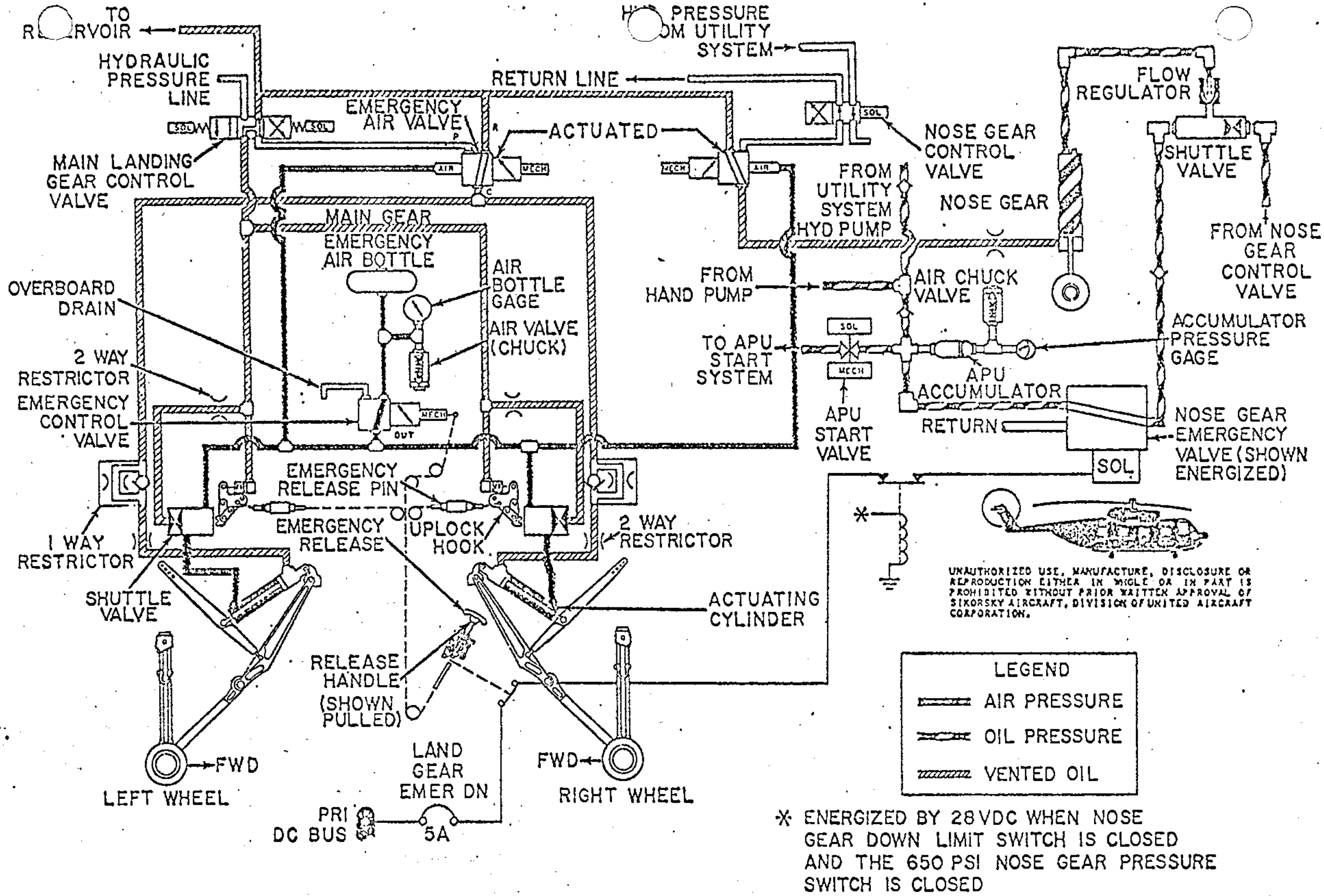
HH-3F
T3.1.1



CABIN HEATER SCHEMATIC

HH-3F
T3.1.71
REV I

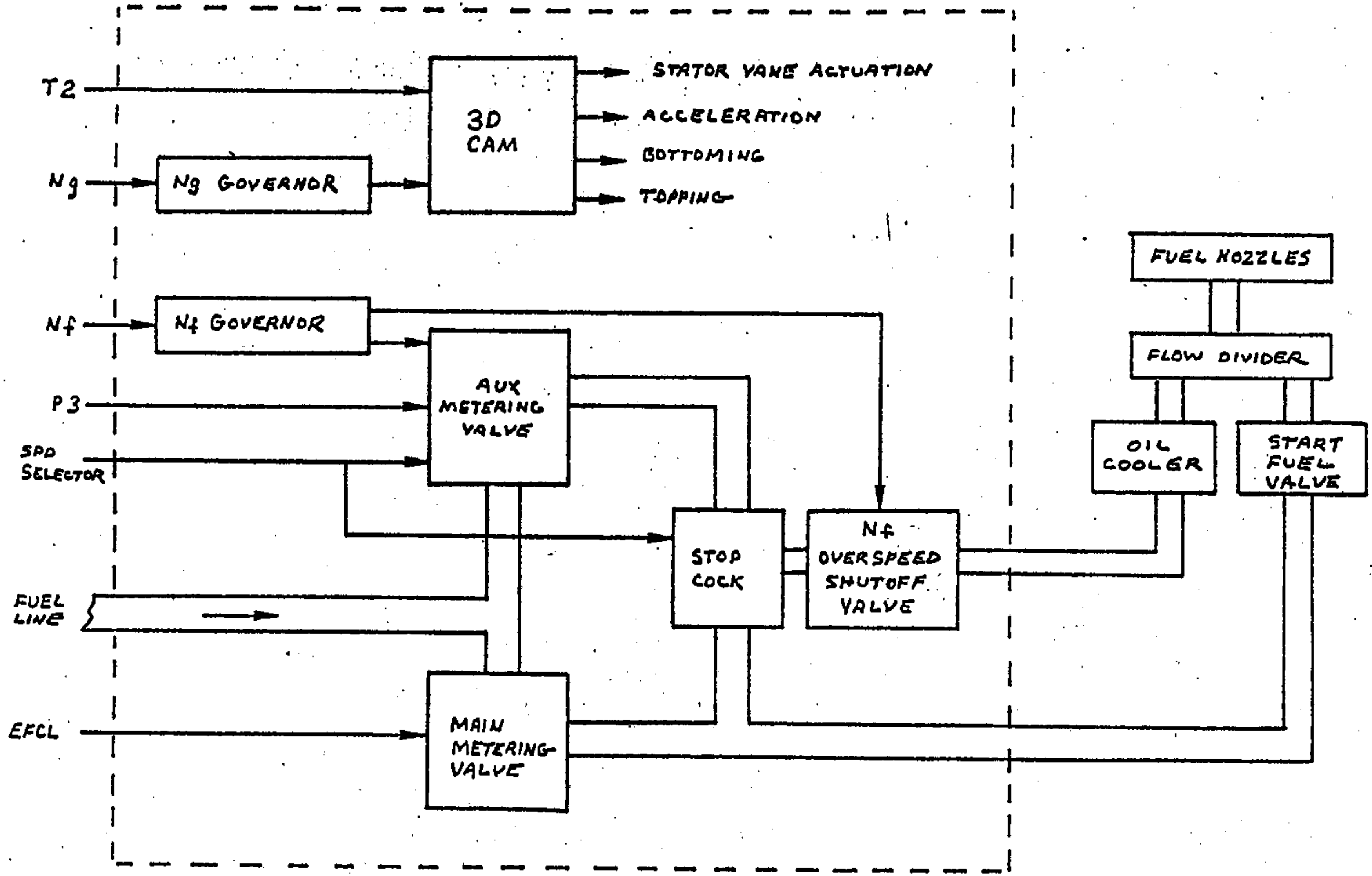
Sikorsky Aircraft



LANDING GEAR EMERGENCY EXTENSION SCHEMATIC

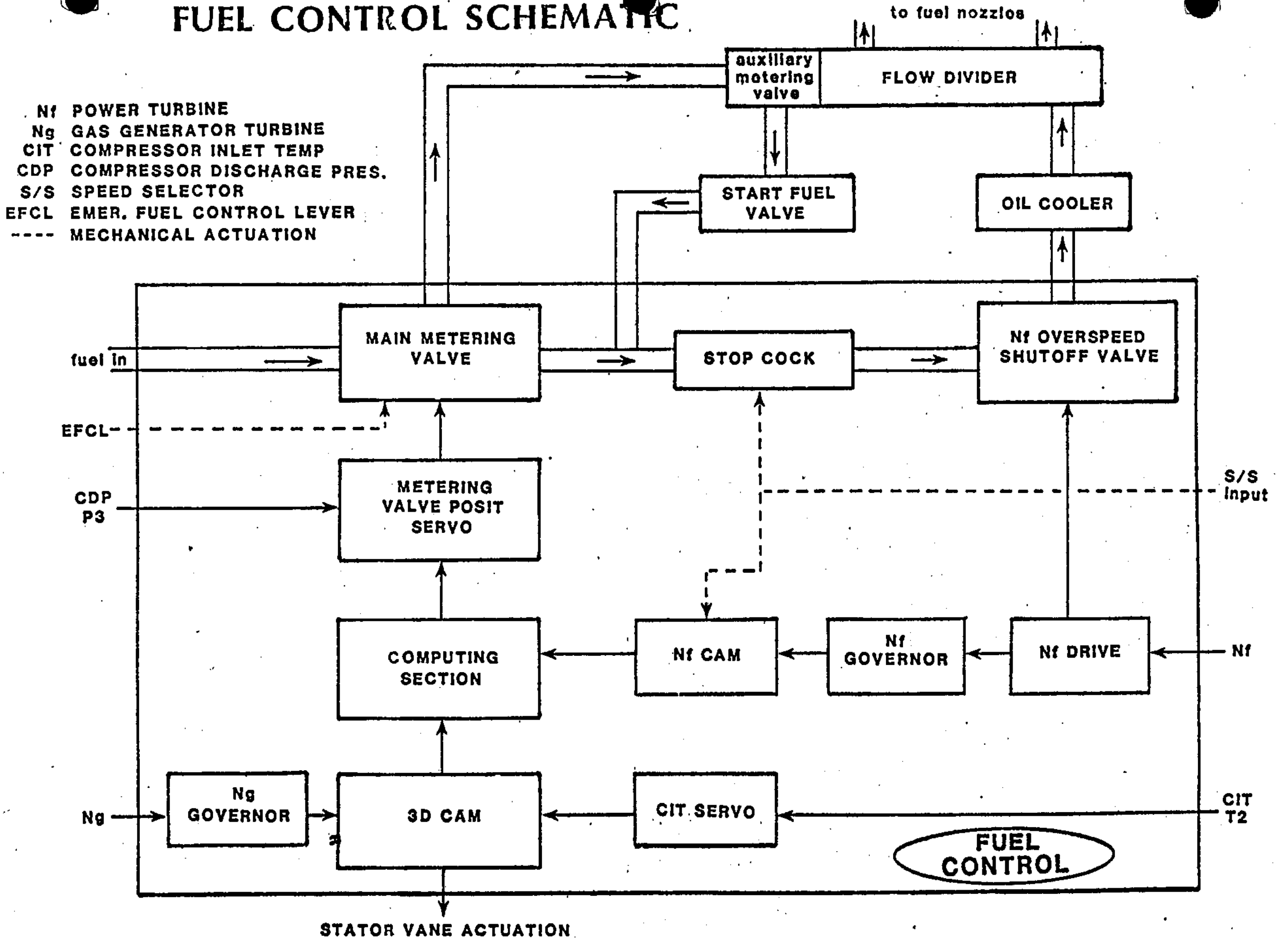
HH-3F
T3.1.29
REV 1

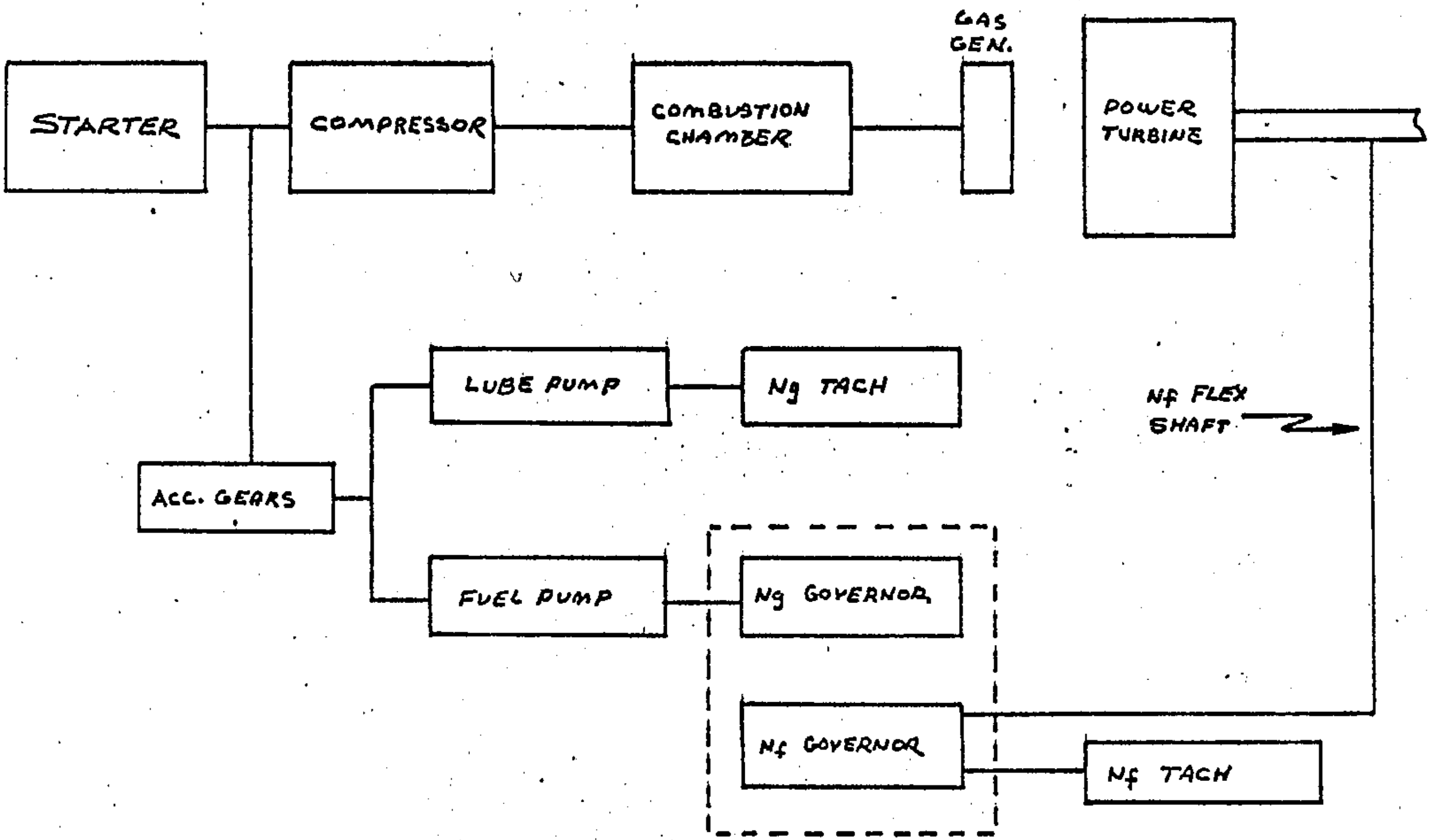
Sikorsky Aircraft



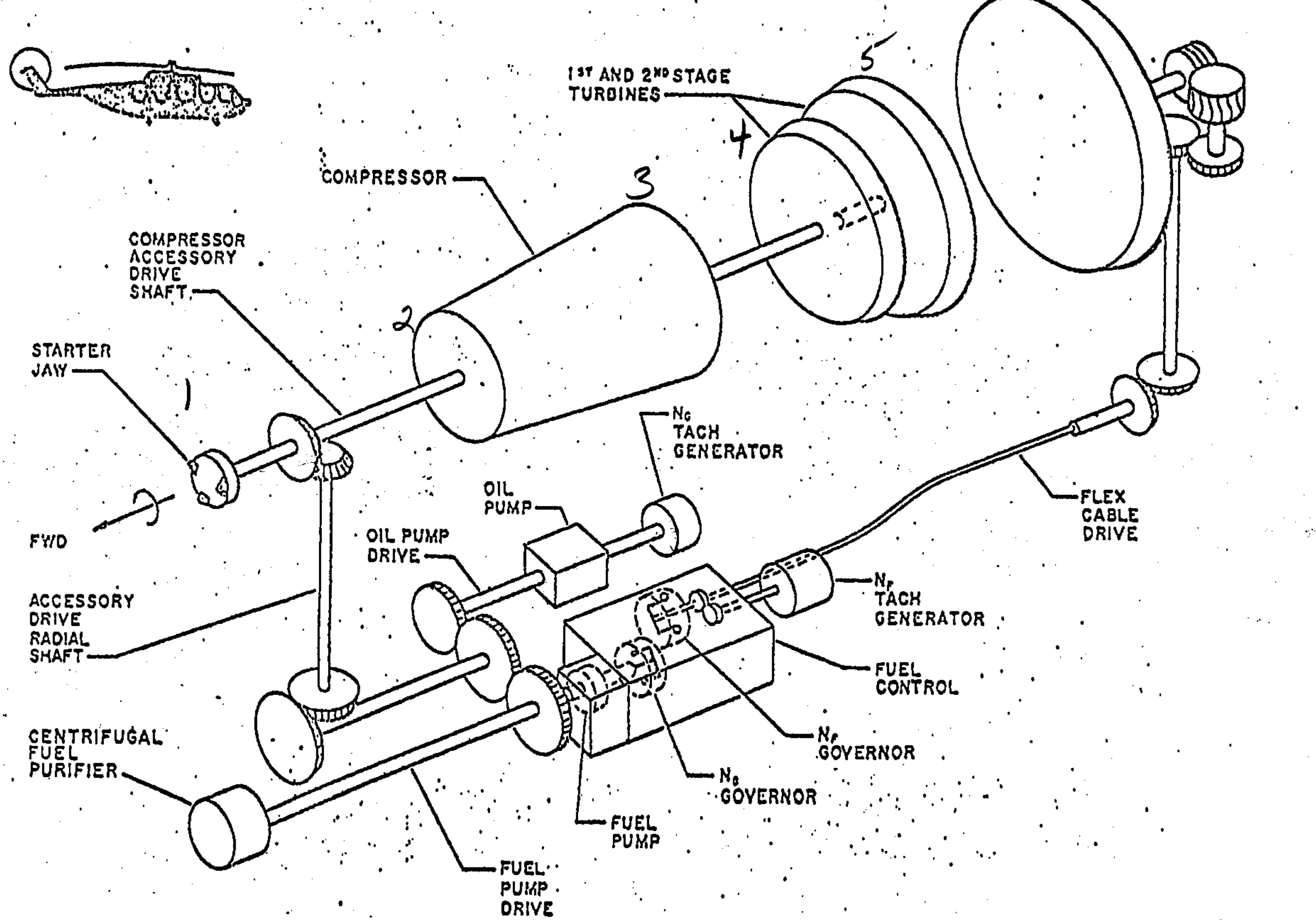
FUEL CONTROL SCHEMATIC

FUEL CONTROL SCHEMATIC





ENGINE SHAFT SCHEMATIC



ENGINE ACCESSORY GEAR TRAIN SCHEMATIC

HH-3F
T2.1.3

INST TAKE OFF

@ TRAINING
PUBLISHED MINIMUMS (CIELING & VIS) — NO LESS THAN 1/2 MI VIS

(b) OPEREATIONAL
1. NEED PUBLISHED VIS FOR CATIGORY (NO ALTERNATE)
2. NEED 1/2 VIS WITH DEPARTURE ALT (PUBLISHED VIS & CIEL... DEPARTURE + 1 HR...

(c) LIFE OR DEATH
NEED PLAN OF ACTION & SEE TO TAXI

DESTINATION: WE NEED ETA ± 1 HR
PUBLISHED MIN. FOR STRAIT IN (1/2 VIS & CIELING)
CIRCLING (1/2 VIS & CIELIN)
NEED ALT IF: 700 - 1 MI OR USE RADAR
ALT MUST BE 700 & 1 MI & 500 ABOVE + 1/2 MI GREATER THAN PUB...
BELOW 10,000 MSL

CONTROL	UNCTROLLED
	CLEAR CLOUDS 1 MI (AVOID EVERYTHING)
	ABOVE 1200 AGL
500 ↓	500
1000 ↑	1000
2000 →	2000
3 MI VIS	VIS SEE AND AVOID (1 MI)

Chapter 3. AIRSPACE

Section 1. GENERAL

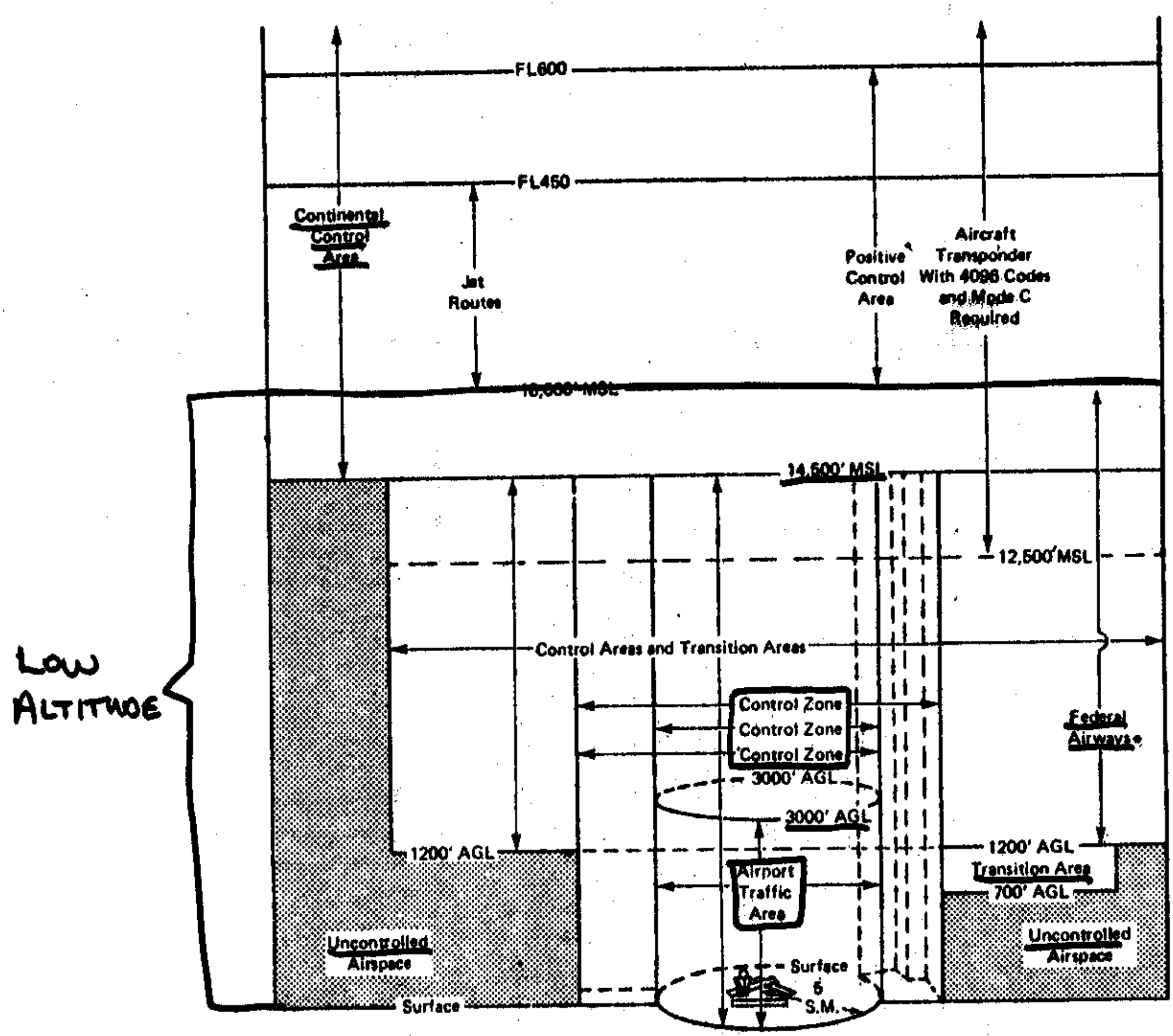
70. GENERAL

Airspace users' operations and needs are varied. Because of the nature of some operations, restrictions must be placed upon others for safety reasons. The complexity or density of aircraft movements in other airspace areas may result in additional aircraft and pilot requirements for operation within such airspace. It is of the utmost importance that pilots be familiar with the operational requirements for the various airspace segments.

71. GENERAL DIMENSIONS OF AIRSPACE SEGMENTS

Refer to FARs for specific dimensions, exceptions, geographical areas covered, exclusions, specific transponder or equipment requirements, and flight operations. Arrows ending near but not touching reference lines mean up to or down to, but not including, the referenced altitude.

NOTE. – *Federal airways in Hawaii have no vertical limits.



72–79. RESERVED

700 & 1 mi DAY VFR
1000 & 3 mi Night VFR

FAR PART 71 & AIM

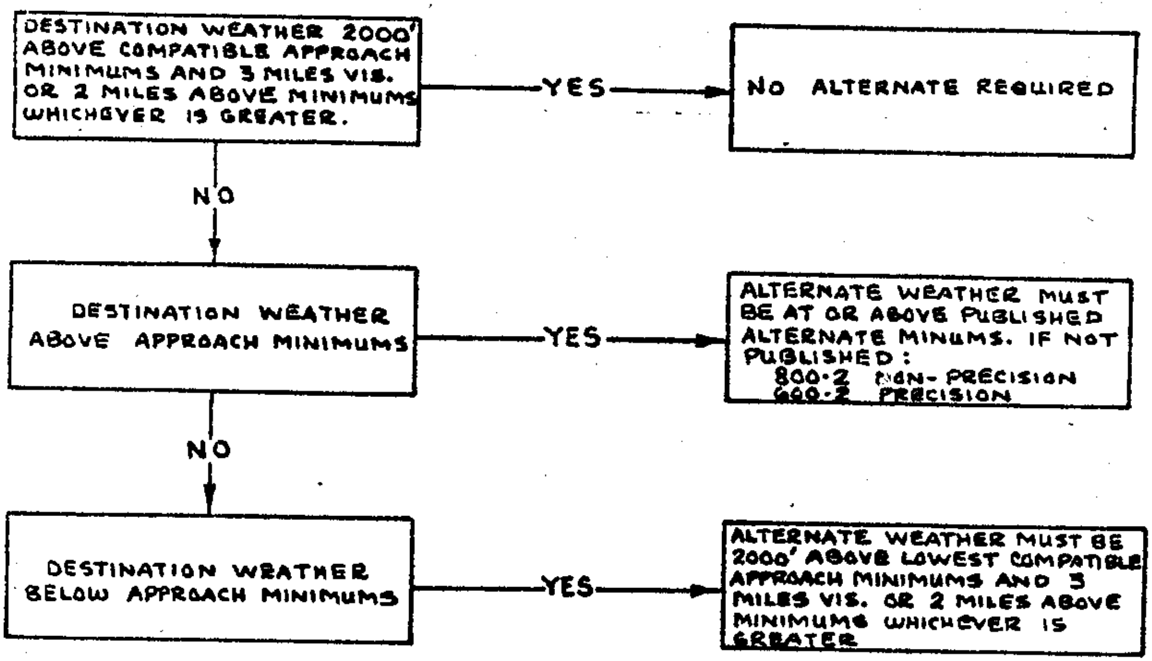
WEATHER GUIDELINES FOR IFR F[illegible]HT

DESTINATION REQUIREMENTS FOR FILING		TIMEFRAME	NOTES
Support Airlift	200' ceiling and 1/2 mile vis (RVR 2400) or lowest min for compatible approach, whichever higher. Intermittent forecast not restrictive, info only.	± 1 hour arrival	eiling and vis required. Vis may reduced by 1/2, no lower than 1/2 mil
Training and evaluation	300' ceiling and 1 mile vis (RVR 5000) or lowest min for compatible approach, whichever higher. Intermit forecast not restrictive, info only.		ceil and vis req. Vis may be reduced by 1/2, no lower than 1 mile, 5000 RVR
Training and evaluation unqual or noncurrent	See 89 MAWR 55-1 pg 1-2		
No published approach	IFR to point where VFR conditions forecast to exist at time of arrival or point where published approach gets aircraft down to VFR conditions.	time of arrival	
WHEN TO DESIGNATE AN ALTERNATE	When filed to airport where radar required to shoot all or portion of published approach. Also, when worst weather is forecast (inter or prevail) less than 700' ceil or 1 mile visibility.	± 1 hour arrival	
ALTERNATE REQUIREMENTS	A ceiling of at least 700', or 500' above lowest compatible landing min, whichever higher, and vis of 1 mile or 1/2 mile above lowest compat landing min, whichever higher. Use worst forecast weather excluding inter conditions due to thunderstorms.	± 1 hour arrival at alternate	May use airfield without inst app as alt. See AFR 60-16 pg 8-2.
TAKEOFF REQUIREMENTS			
Support Airlift	200' ceiling and 1/2 mile vis (RVR 2400) or lowest, lowest min for compatible approach, whichever higher.	existing weather	
	Vis may be reduced to 1/2 required published vis (No lower than 1/2 mile or RVR 2400) if departure alternate is used.		copter only app vis will be used as published. S[illegible] MACR 55-1[illegible] dep alt required
Training and Evaluation	300' ceiling and 1 mile vis (RVR 5000) or lowest min for compatible approach, whichever higher. Vis may be reduced to 1/2 required published vis (no lower than 1 mile or RVR 5000) if departure alternate used.	existing weather	
Training and Evaluation unqual or noncurrent	See 89 MAWR 55-1 pg 1-2		
APPROACH MINIMUMS	May use 1/2 published vis, but not less than RVR 1200 or 1/4 mile. Circling approaches also require ceiling.	existing weather	copter only app will be used as published

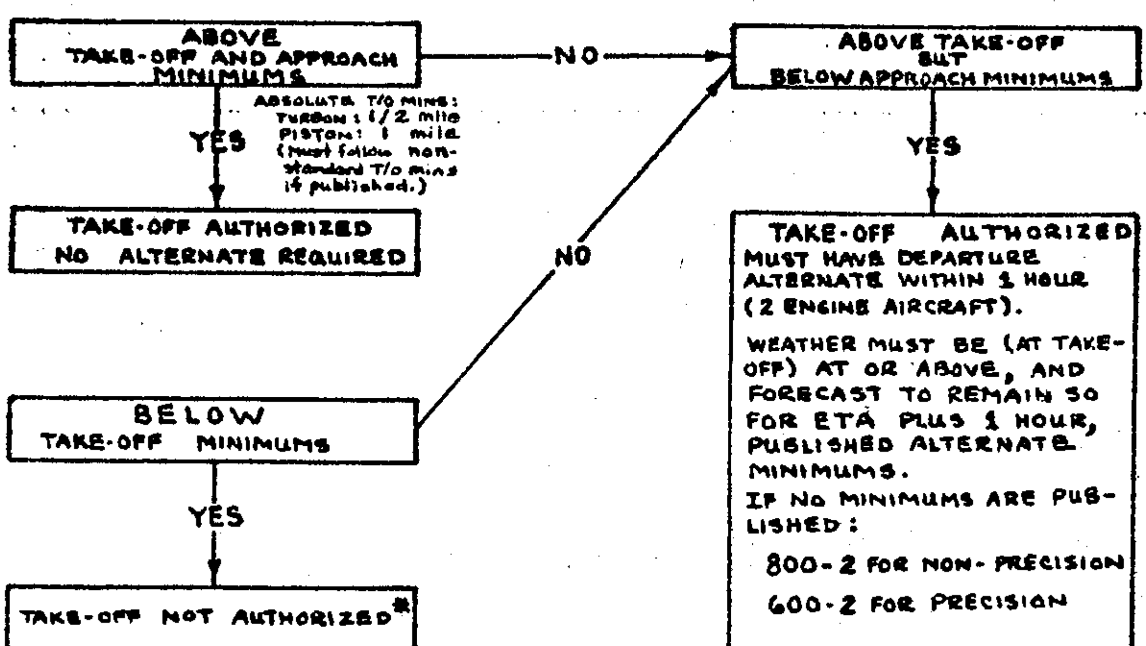
WILLIAM J. FITZGERALD

FLIGHT SAFETY OFFICER
U. S. COAST GUARD AIR STATION
ELIZABETH CITY, NC 27909

DESTINATION WEATHER



DEPARTURE WEATHER



* The Commanding Officer of A/S may authorize TAKE-OFF in this situation if mission urgency dictates.